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ABSTRACT

The Auditory Automotive Mechanics Diagnostic Achievement Test assesses an automobile mechanic's ability to determine mechanical faults from auditory cues alone. The 44-item test and its instructions are recorded on magnetic tape; answer choices are presented on tape, and are also written in the printed test booklets. The norming and validity sample consisted of four groups: an inexperienced group of 67 high school students, 91 students who had completed half of a two-year course in automotive mechanics, 67 graduates of that course, and 44 experienced auto mechanics. The reliability was low for the total group, but increased to .738 when eight non-discriminating items were deleted. The validity of the test was shown by differences in the mean scores of the four groups, and by correlations with peer ratings among groups of auto mechanics students. Factor analysis of the test items resulted in three factors that could be interpreted and three other factors. Correlations with other auditory tests were found to be generally low, except for the Tonal Memory Test and the Hidden Tunes Test. A moderate correlation was found with a written achievement test of knowledge of auto mechanics. Descriptions of some standardized tests of auditory-perceptual abilities, compiled in 1957, are appended. (CTM)

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AUDITORY AUTOMOTIVE MECHANICS DIAGNOSTIC ACHIEVEMENT TEST

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PREFACE

For a doctor, the ability to listen to a heartbeat with a stethoscope and analyze the sound in terms of a person's health is extraordinarily important. It allows him to make rapid preliminary diagnoses without the necessity for detailed electronic or visual examinations. This is absolutely vital in life-or-death cases, but important as well in the doctor's day-to-day round of treating his patients. Few people would be willing to submit to X-Ray examinations simply to determine that their lungs were congested. Yet, while we take the doctor's auditory diagnostic ability for granted, we seldom consider that people in other occupations also use their hearing in ways that are very important.

This paper presents the Auditory Automotive Mechanics Diagnostic Achievement Test, a test designed to assess the mechanic's ability to determine mechanical faults from auditory cues. The auditory diagnostic ability of a mechanic is of obvious importance in his occupation. He does not have the time, nor does the public have the money, to dismantle every automobile engine for visual inspection or perform complex electronic evaluations, so he must be able to use his ears to limit the area of his search for a mechanical problem.

There are also broad implications arising out of this test for other behaviorally oriented tests. Dr. Swanson has underscored the need for the development of instruments which are oriented toward testing behavioral characteristics, rather than simply relying on paper and pencil tests. After all, a physician might know all the textbook characteristics of a congested lung, but he would be of little value if he could not recognize it when he heard it through his stethoscope.

The Center would like to extend its appreciation to Dr. T. S. Baldwin, Associate Professor of Education, University of North Carolina at Chapel Hill, for his part in reviewing the paper. Another review was provided by John K. Coster of the Center for Occupational Education.

The contribution of the Center's clerical and editorial staff is also gratefully acknowledged.

John K. Coster
Director

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CHAPTER I

INTRODUCTION

Nature of the Problem

Instructional programs are in many cases evaluated with readily available, and often inadequate, criteria for the sake of expedience. This is done instead of carefully analyzing what the student is supposed to be able to do as a result of his training and stating this in behavioral terms.

These readily available and more easily developed criterion instruments are usually of the paper and pencil type. They fail most vividly in the practical arts areas of education to measure the gamut of behavioral changes expected of students. Even with this known deficiency little has been done in the way of developing performance tests. They have lagged far behind as a result of their many inherent obstacles. Performance tests take more time to develop and administer, are more expensive, and are less comprehensive than paper and pencil tests (Evans, 1953, p. iii). Another explanation of their lag in development is ". . . presumably because of their lesser practical importance (Gagne and Fleishman, 1959, p. 117)."

The question of the importance of performance testing is a logical one. If a test is to represent the ultimate criterion the dimensions of the criterion must be analyzed and tested accordingly. Numerous studies have shown that the criterion of success in most jobs is multidimensional. Because a person has a comprehensive understanding of automotive operational theory does not imply that he is an outstanding manipulator of automotive tools and equipment. For a truly representative test each dimension of the criterion needs to be assessed, particularly where the several dimensions are uncorrelated. If an automotive tool and equipment manipulative test were developed it would probably not replace the paper and pencil test. Instead, it would add an additional dimension to the assessment of an automotive mechanic's ability. More important, it would give the mechanic credit for that important dimension of the criterion he has learned.

The trained human senses play a significant role in the performance of people in the trades. Of the senses audition is felt to be of great importance by many authorities. Fleishman and Friedman (1957, pp. iii-iv), and Gagne and Fleishman (1959, p. 117) stress the importance of the relation of the human auditory system to the practical consequence of employment opportunities. Saupe's (1954) research on electronic equipment trouble shooting points out the importance of auditory diagnostic work even in an area that is largely dependent upon electrical and mechanical test equipment. Of the eight malfunctions he selected as being representative of the requirements of an electronics technician each had an auditory cue. Six of the eight had auditory cues that were unique to the particular malfunction. Moore (1967, p. 14) states that sensory cues, and especially auditory cues, make up a significant portion of the diagnostic time an automotive mechanic spends in the course of his work.

Many of the text books in the trades and technologies make an attempt to describe audible sounds. Crouse (1955, 1960), who has written some of the most widely used texts in automotive mechanics, has devoted sections to describing malfunctioning sounds. The most significant support for the importance of auditory diagnostic work in auto mechanics comes from the men working in the trade. Interviews with these men have confirmed the importance of the trained human ear in diagnosing automotive malfunctions. "With the existence of today's wealth of sophisticated test equipment, it is easy to overlook the role that a high degree of sensitivity to automotive sounds plays in diagnostic procedures. The fact remains that a 'trained ear' continues to be an important tool of the auto-service technician (Welch, 1968, p. 88)."

Purpose of the Study

The purpose of this study was to develop and validate a test to measure an additional dimension of performance in automotive mechanics that is not being measured by more conventional paper and pencil tests. Specifically, this test attempts to measure the ability to diagnose malfunctions in automobiles through the auditory sense. The test is referred to as the Auditory Automotive Mechanics Diagnostic Achievement Test (AAMDAT).

Limitations of the Study

It was not a part of this study to assess all the dimensions of the performance criterion of an automotive mechanic. Nor was there an attempt to determine the relative importance of the dimensions. This study was designed only to develop an instrument for assessing one dimension of the criterion, the ability to diagnose automobile malfunctions through the auditory system.

CHAPTER II

REVIEW OF THE RESEARCH ON AUDITION

There is a trend toward a greater use of the auditory sense for the transmission of information. One reason for this is that the visual channel has become overburdened (McCormick, 1957, p. 168). As a result, studies have reported that in many cases instruction through the auditory channel is more efficient than instruction through the visual channel (Hoehn and Lumsdaine, 1958).

Basic Research

Basic research has demonstrated the independence of the various psychological dimensions of audition (Davis, 1947). For example, the psychological dimension of pitch is dependent primarily upon frequency. The fact that a tuning fork vibrates at 440 cycles per second with varying loudness in successive tries does not interfere with the discrimination of these 440 cycles. Loudness discrimination, on the other hand, is a psychological attribute of audition that is closely related to intensity and slightly related to frequency. As sounds get below or beyond the middle range (500 - 4,000 cycles per second) loudness discrimination is more difficult. The several other psychological attributes of audition depend upon particular combinations of frequencies and intensities. What constitutes the remaining psychological dimensions of audition has not always been agreed upon. Those that are generally accepted are quality (timbre), time, rhythm, and auditory memory (Karlin, 1942, p. 251).

Individual physical attributes also provide further explanation of differences in auditory ability. One theory of audition suggests the stimulation of certain fibers causes us to hear a high-pitched tone, and the stimulation of others, a low-pitched tone (Fogel, 1963, p. 130). The several other audition theories also provide explanations supporting the position that as people differ physically so do their abilities to discriminate within the psychological dimensions of audition. These elementary, yet significant, findings on the independence of the dimensions of audition provides guidance in the development and evaluation of specific auditory achievement tests.

Other areas that basic researchers in audition have investigated are how illumination, gastatory stimulation (Kekcheer, 1947), and pressure (Close and

and Ireland, 1960) affect auditory thresholds. Studies of this type have little or no implication for this investigation.

One area of the basic research did raise a question for investigation in the future. This is the question of the independence of the auditory and visual channels. Both Fleishman (1957) and Ware (1961) found the auditory and visual channels to be relatively independent. Gruber (1964) and, more significantly, McGrath (1965) found the opposite to be true. McGrath reported that detection of high fidelity auditory cues was significantly higher when monitored with low fidelity visual cues than with auditory cues alone. The implication here is to assess the independence of these two sensory dimensions in an applied situation using high fidelity audio cues alone and then along with the low fidelity visual cues.

Applied Research

Compared to basic research there is almost a complete void in the applied research area of audition.

A few classical studies have been done. One is Seashore's (1919) Measures of Musical Talent. Seashore developed tests to measure five elements of music;

(1) pitch, (2) timbre, (3) time, (4) tonal, and (5) loudness. These tests have been standardized and are still available. The reported reliabilities of these sub-tests have ranged from .62 to .88 (Mursell, 1949, p. 177). After all these years it is amazing to find the validity of this test battery has never been established (Wing, 1955, p. 230).

A more recent study by Fleishman and Friedman (1957) was concerned with developing an auditory test battery for selecting air force radiotelegraphy operators. They noted the commonality between the musical auditory dimensions identified by Seashore and the auditory discrimination required in radiotelegraphy work. Using the Seashore test, and with the inclusion of several tests of their own, they proceeded to establish the predictive value of these instruments. Their additional tests had reliabilities ranging from .83 to .98. Validity was again a problem in the Fleishman and Friedman battery. The validity coefficients of the sub-tests to a radiotelegraphy proficiency criterion ranged from -.40 to +.39. No multiple correlation was reported. From what is known of the independence of these measures it would seem to be of a size to warrant further serious investigation.

Although Fleishman and Friedman originally designed their auditory aptitude battery for selecting personnel for a specific job, they were later led to believe it had a more general utility for predicting success in any job where auditory discrimination is critical. This was because of the close relationship of the psychological dimensions of audition as measured by their battery to the requirements of most real life auditory discrimination situations.

CHAPTER III

DEVELOPMENT OF THE HYPOTHESES

The broad research objective of this study was to develop and validate a test to assess the ability to diagnose malfunctions in automobiles through the auditory sense.

The process of test validation has become somewhat standardized over the years. The American Psychological Association publication entitled "Standards for Educational and Psychological Tests and Manuals" (1966) summarizes this process. It was used here in the development of the research hypotheses.

Test reliability is one of the requirements of a good test. Reliability may be thought of as the consistency or stability of measurement by a test (APA, 1966, p. 25). In order to determine the reliability of the AAMDAT the following hypothesis was generated.

> Research Hypothesis I - Auditory diagnostic ability exists as a reliable dimension as measured by the AAMDAT.

The validity of a test may be thought of as the degree to which the instrument achieves its purpose (APA, 1966, p. 12). Validity is measured in several ways. They are content, construct, concurrent, and predictive validity (Cronbach, 1960, p. 108).

Determining content validity is a somewhat subjective procedure. For this study no formal hypothesis of content validity was stated. The process used for obtaining content validity is discussed in the Test Development portion of Chapter IV.

Construct validity is evaluated through the investigation of a theoretical construct that accounts for performance on a test (APA, 1966, p. 13). The theoretical construct in this study is auditory diagnostic ability. Validation of the construct occurs if people with more experience achieve higher on the AAMDAT. A hypothesis involving the four samples of varying experience used in this study was developed to test the construct validity of the AAMDAT.

> Research Hypothesis II - The achievement on the AAMDAT by experienced automotive mechanics is significantly higher than that of graduating automotive mechanics students, whose achievement is in turn significantly higher than first year students, whose

> achievement is in turn significantly higher than students who have had no training or experience.

Concurrent validity of a test is demonstrated through a comparison of test scores with another measure of the same dimension (APA, 1966, p. 13). Because of the lack of another test of auditory diagnostic ability it was difficult to assess the concurrent validity of the AAMDAT. It was necessary to use an intermediate criteria. The intermediate criterion of peer nominations was selected even though no research evidence was available on how well peers can assess auditory diagnostic ability. This method has shown itself to yield results that correlate highly with more complex criterions such as longitudinal success in leadership ability (Wherry, 1949; Hollander, 1956). Reliabilities have been reported to be in the high .80's (Wolins, 1956). Using this intermediate criteria of auditory diagnostic ability the concurrent validity of the AAMDAT was tested through the following hypothesis.

> Research Hypothesis III - The achievement on the AAMDAT is highly correlated to peer nominations on the same dimension.

Most behavior is multidimensional. In the review of the research the fact that there are independent dimensions of audition was established. In an attempt to determine whether or not there are independent dimensions of auditory diagnostic ability the following hypothesis was established.

> Research Hypothesis IV - There are significant independent dimensions of auditory diagnostic achievement.

The earlier discussion of the Seashore, Fleishman, and Friedman applied research in audition raises questions about predictive validity. Seashore's Musical Talent Test never was validated as a predictor of success in the complex field of music. On the other hand the Fleishman and Friedman Aptitude Battery was moderately successful in predicting success in the simplier field of radiotelegraphy. The question of how well auditory aptitude predicts auditory diagnostic ability in auto mechanics is raised. The Fleishman and Friedman Auditory Aptitude Test Battery was selected for use in this study to determine this relationship. It was felt that their aptitude tests more closely represented the discrimination needed in auditory automotive diagnostic work than did the pure tone type aptitude tests. An example here is the inclusion of the rhythm test in the Fleishman and Friedman battery and the fact that many malfunctioning sounds in automobiles are rhythmic. Not having any strong evidence one way or the other as to the predictive potential auditory aptitude has in this field the hypothesis was stated in the null form.

> Research Hypothesis V - There is no significant correlation between achievement on the AAMDAT and the Auditory Aptitude Battery.

The early discussion in the introduction of this study suggests that performance tests provide measures that are not necessarily related to paper and pencil test achievement in the same field. In order to evaluate the independence of the AAMDAT from achievement on auto mechanics paper and pencil test this last hypothesis was generated.

> Research Hypothesis VI - Achievement on the AAMDAT does not correlate significantly with achievement on a paper and pencil automotive mechanics test.

CHAPTER IV

PROCEDURE

Test Development

Logical rather than statistical methods are used to assess the content validity of a test (DuBois, 1965, p. 40[illegible]). The method should be systematic and thorough. One such systematic approach that can be used for determining content validity is through a job analysis. Basically there are two types of job analyses. The first involves direct observations by the investigator and the second involves judgements by individuals other than the investigator (Bechtoldt, 1949, p. 1248). This second method was used in this study for determining those malfunctions an automotive mechanic is required to diagnose through the auditory sense.

In this study a staff of automotive mechanics instructors and automobile mechanics was available for consultation. These content experts acted as the judges. Their lists of potential audible automotive malfunctions were compiled in a one-way outline as suggested by Wood (1961, p. 34). The potential test items for each of the automobile systems were then ranked independently by all the judges from most to least important (Appendix A). Those malfunctioning sounds that received the highest combined rank were selected for inclusion in the test.

The goal was to develop a test having from forty to sixty auditive malfunctions that would take approximately one hour to administer. The completed test, one hour in length, had a total of forty-five items. These malfunctions were built into automobiles; e.g., installing a bad connecting rod bearing into an otherwise perfectly running engine. Using a high quality binaural recording-reproducing system (Appendix B) the malfunctioning automobiles were recorded.

Many technical difficulties were encountered in the recording process. Positioning of the microphones between a block of styrofoam to simulate the human head seemed most satisfactory for the binaural effect. The setting of one microphone for low frequency pick-up and the other for high frequency pick-up produced the most realistic recordings. Automobile electrical interference, bouncing sound waves, and proper malfunction to total automobile noise demanded a new recording technique for almost every malfunction. The extreme sensitivity of the recording equipment made even the most subtle environmental sounds a nuisance. The final recordings, along with recorded instructions, made up the test (Appendix C).

The Auditory Aptitude Test Battery (Appendix D) was shortened for use in this study. This was done to keep the total auditory achievement and aptitude testing time within a two and one half hour time limit. It was felt that subjects who were not accustomed to wearing headsets would become fatigued if the testing time were any longer. The Code Distraction Test, which is identical to the Dot Perception Test except for background noise, was eliminated from the battery because of their high correlation. Fleishman and Friedman (1957, p. 7) reported their correlation to be .82. The Signal Corps Code Aptitude Test and the Army Radio Code Test were eliminated from the battery because of their very specific nature. The remaining subtests were reduced in length. The reliabilities for the reduced forms, as predicted by the Spearman-Brown prophecy formula, are presented in Table 1. These odd-even reliabilities reported by Fleishman and Friedman for their speeded auditory aptitude tests are probably overestimates since this method of determining reliability is not the most appropriate for speed tests.

TABLE 1

ESTIMATED RELIABILITIES OF THE SHORTENED FORMS OF THE AUDITORY APTITUDE SUB-TESTS

Sub-tests	Total		Shortened	
	Scored Items	Odd-even Reliability*	Scored Items	Estimated Reliability
Pitch Discrimination	50	.86	30	.77
Loudness Discrimination	50	.63	30	.51
Rhythm Discrimination	30	.90	20	.86
Time Discrimination	50	.73	30	.62
Timbre Discrimination	50	.79	30	.70
Tonal Memory	30	.88	20	.83
Copying Behind	240	.98	120	.96
Dot Perception	160	.94	80	.89
Hidden Tunes	50	.83	30	.68

*Fleishman and Friedman, 1957.

Description of the Samples

Four distinct populations were sampled for this study (Appendix E). The first sample consisted of high school seniors having little or no experience with automobiles (No Experience Group). These students were drawn from general English classes of Central High School, Champaign, Illinois. A total of sixty-seven subjects were tested.

The second and third samples were post high school technical automotive mechanics students. The second sample consisted of students who had completed one of their two years of training in automotive mechanics (First Year Auto Mechanics Students) and the third consisted of students graduating from the two year programs (Graduating Auto Mechanics Students). The automotive mechanics students tested were from North Carolina, South Carolina, and Georgia. Ninety-one first year and sixty-seven graduating students were tested.

The fourth group consisted of auto mechanics who had an average of over twelve years of on the job experience (Auto Mechanics). Forty-four mechanics from Illinois and Indiana University motor pools were secured for this sample.

Test Administration

The no experience and auto mechanics samples received the AAMDAT only. Administration of the AAMDAT was followed by the administration of the Auditory Aptitude Test Battery (Appendix D) for the first year and graduating auto mechanics students. The aptitude test was used to determine the relationship between auditory aptitude and auditory diagnostic achievement. The graduating auto mechanics students also received the paper and pencil Auto Mechanics Achievement Test (Baldwin, 1966) to determine the relationship between these two measures.

The recorded automotive diagnostic test and the Auditory Aptitude Battery were transmitted to the subjects through headsets. This eliminated the variables of positioning and acoustics involved in speaker sound transmission. AAMDAT item alternatives were presented on test booklets as well as on the recording. As was mentioned previously, all instructions were included on the tape recording to permit the test to be administered by untrained personnel in the future.

Evaluation of the Hypotheses

Research Hypothesis I - Auditory diagnostic ability exists as a reliable dimension as measured by the AAMDAT.

To evaluate Hypothesis I, the reliability of the AAMDAT, the appropriate Kuder-Richardson formula was selected once the test items were analyzed and further assumptions about the test could be made. An odd-even test reliability was also computed. The test-retest method of reliability was impractical because of the logistics involved in the testing. Since the AAMDAT is primarily a power test the K-R series and odd-even reliability are appropriate.

> Research Hypothesis II - The achievement on the AAMDAT by experienced automotive mechanics is significantly higher than that of graduating automotive mechanics students, whose achievement is in turn significantly higher than first year students, whose achievement is in turn significantly higher than students who have had no training or experience.

A simple one-way analysis of variance and separate group t tests were computed to evaluate this second research hypothesis.

> Research Hypothesis III - The achievement on the AAMDAT is highly correlated

to peer nominations on the same dimension.

Hypothesis III was evaluated through the computation of separate product moment correlations between AAMDAT scores and peer nominations for the first year auto mechanics students, graduating auto mechanics students, and for the auto mechanics.

Research Hypothesis IV - There are significant independent dimensions of auditory diagnostic achievement.

The items on the AAMDAT were factor analyzed. A principle axes factor analysis was performed to reduce the item inter-correlations to a few underlying dimensions. Because difficulty often occurs in psychologically describing factors once they have been mathematically identified some forethought was given. A questionnaire for obtaining information from the subjects was developed in the hope that this information would help explain high inter-item correlations (Appendix F).

Research Hypothesis V - There is no significant correlation between achievement on the AAMDAT and the Auditory Aptitude Battery.

Product moment correlations between the auditory aptitude sub-tests and the AAMDAT for graduating and first year students, and the multiple correlation of the total aptitude battery for the graduating auto mechanics students were computed. This was done to assess the predictive validity of the aptitude test battery when the AAMDAT was used as a criterion. Logistically it was impossible to assess the predictive validity by administering the Auditory Aptitude Test Battery to all those persons applying for positions and then compare their results to later achievement on the AAMDAT. For this reason the concurrent measures of auditory aptitude and AAMDAT achievement were used to estimate the predictive validity.

> Research Hypotheis VI - Achievement on the AAMDAT does not correlate significantly with their achievement on the paper and pencil automotive mechanics test.

Research Hypothesis VI was evaluated by using a product moment correlation to test the independence of these two measures for the graduating auto mechanics students.

CHAPTER V

ANALYSIS AND DISCUSSION OF THE DATA

Test Items

Item information and item analysis for the total group and for each of the four samples are presented in Appendix G. This information includes the correct response, proportion passing, proportion selecting each response, and biserial correlation of item to total test scores.

Careful study of these tables point to the ineffectiveness of several of the test item distractors. In future revision of this instrument these distractors should be eliminated or reworked to correct for their weaknesses.

The biserial correlations of the test items to the test total scores would also be of assistance in the test revision. Items that were selected because of their relevance to job performance and yet discriminate poorly should be reviewed for possible revision. Items that have low or negative correlations with total performance may not necessarily be related to item distractor effectiveness. In this test the recordings must be evaluated, as well as the stem and item distractors, to assess item effectiveness.

Research Hypotheses

Research Hypothesis I

Table 2 contains the Kuder-Richardson formula 14 and the odd-even (with the Spearman-Brown prophecy correction) tests of reliability.

TABLE 2

AAMDAT RELIABILITY

Groups	N	KR-14	Odd-Even	Range
No experience subjects	67	.335	.201	8 - 25 17 points
First year auto mechanics students	91	.433	.448	11 - 30 19 points
Graduating auto mechanics students	67	.436	.235	13 - 39 16 points
Auto mechanics	44	.252	.268	20 - 33 13 points
Total	269	.710	.674	8 - 33 25 points

They are presented for the no experience, first year auto mechanics students, graduating second year auto mechanics students, auto mechanics, and the total group. The reliabilities were calculated for the forty-four scored Auditory Automotive Mechanics Diagnostic Achievement Test questions.

The Kuder-Richardson formula 14 calculations are considered the best estimates of the reliability of the AAMDAT. The KR-14 assumes equal item intercorrelations and a single underlying factor. The odd-even test of reliability makes the same assumptions as the KR-14, plus the assumption that there is equal item standard deviation. This additional assumption cannot be accepted for this data. Therefore, the odd-even reliabilities are theoretically underestimates.

The low reliabilities within the selected samples are partially accounted for by the inclusion of ineffective test items and the limited range of scores. In an attempt to improve the reliability, the items (5, 7, 12, 18, 25, 33, 38, and 40) that appeared least efficient according to the point biserial correlations were eliminated. The odd-even reliabilities were recalculated to get an appreciation of the effect on the reliability from this minimal test revision. They are presented in Table 3. A consistent increase in the reliability is evident. An even greater increase would be expected from the recomputation of the KR-14 reliability, since it more closely represents the data.

TABLE 3

AAMDAT RELIABILITY WITH THE POOR TEST ITEMS* ELIMINATED

Groups	N	Total Test KR-14	Total Test Odd-Even	Shortened Test Odd-Even
No experience subjects	67	.335	.204	.230
First year auto mechanics students	91	.433	.448	.599
Graduating auto mechanics students	67	.436	.235	.333
Auto mechanics	44	.252	.268	.278
Total	269	.710	.674	.738

*Items 5, 7, 12, 18, 25, 33, 38, and 40 eliminated.

In terms of the total sample of subjects participating in this study it may be said that the AAMDAT is a reliable instrument. It should be pointed out, however, that caution is necessary in interpreting this coefficient. It is unlikely that the test would ever be used on a population as heterogenous as the total sample in this study and therefore, this coefficient is of little practical value. It was computed here only to indicate the influence of increasing the range of individual differences. Nevertheless, the total sample of subjects retaking the test would for the most part maintain their relative positions.

The AAMDAT reliabilities within the more selective sub-groups are not high enough to warrant making fine distinctions among test achievement for these subjects. There has been data presented here supporting the belief that a revision of the AAMDAT would greatly increase its ability to make these fine discriminations.

Research Hypothesis II

In order to support the theoretical construct that auditory diagnostic ability increases with auditory diagnostic experience a comparison of the achievement of the subjects in the four different experience groups was made. This was done through the computation of a simple one-way analysis of variance and is presented in Table 4.

The F value was found to be significant beyond the .0001 level. The theoretical construct that increasing auditory diagnostic experience increases auditory diagnostic ability was supported.

TABLE 4

ANALYSIS OF VARIANCE OF AAMDAT ACHIEVEMENT SCORES OF GROUPS HAVING VARYING DEGREES OF AUTOMOTIVE EXPERIENCE

Source of Variation	Sum of Squares	df	Mean Square
Between groups	4,565	3	1,521.66
Within groups	3,750	265	14.15
Total	8,315	268	

df= 3 F= 107.54 (p < .0001)

For further support the means of the four experience groups were examined for significant differences. Several t tests were computed and are presented in Table 5. The auto mechanics achieved significantly higher (p < .0005) than the graduating auto mechanics students. The graduating auto mechanics students achieved significantly higher (p < .01) than the first year auto mechanics students. Finally, the first year auto mechanics students achieved significantly higher (p < .0005) than the no experience group.

Research Hypothesis III

The concurrent validity of the AAMDAT was evaluated through the testing of Hypothesis III

TABLE 5

ONE TAILED t TESTS OF SIGNIFICANCE BETWEEN AAMDAT MEANS OF GROUPS HAVING DIFFERENT LEVELS OF EXPERIENCE IN AUTOMOTIVE MECHANICS

Auto Mechanics and Graduating Auto Mechanics Students

Groups	N	ϵX	$\bar{X}$	ϵX^2
Auto mechanics	44	1,169	26.57	31,533
Graduating auto mechanics students	67	1,555	23.21	37,083

df = 45.5 t = 4.87 ($p<.0005$)

Graduating Auto Mechanics Students and First Year Auto Mechanics Students

Groups	N	ϵX	$\bar{X}$	ϵX^2
Graduating auto mechanics students	67	1,555	23.21	37,083
First year auto mechanics students	91	1,969	21.64	44,009

df = 78 t = 2.50 ($p<.01$)

First Year Auto Mechanics Students and No Experience Subjects

Groups	N	ϵX	$\bar{X}$	ϵX^2
First year auto mechanics students	91	1,169	21.64	44,009

TABLE 5 (Continued)

Groups	N	εX	$\bar{X}$	εX^2
No experience subjects	67	971	14.49	14,949

df = 78 t = 11.79 ($p<.0005$)

separately for the first year auto students, the graduating auto students, and the auto mechanics.

The peer nomination technique was chosen as the second measure of auditory diagnostic ability in auto mechanics because of the lack of another achievement test in this area. The nominations received by the first year auto mechanics students, graduating auto mechanics students, and the auto mechanics were first converted into standard scores by sub-groups. The sub-groups consisted of the subjects in a single class or shop. These standardized peer nomination scores were then correlated to the AAMDAT achievement for each of the three groups. These correlation coefficients are reported in Table 6.

The first year students had a .256 ($p<.05$) correlation between the two measures. The graduating students had .327 ($p<.01$) correlation coefficient and the auto mechanics had a .161 correlation.

TABLE 6

PEER NOMINATION TO AAMDAT ACHIEVEMENT CORRELATION COEFFICIENTS

Group	N	Correlation
First year auto mechanics students	76	.256*
Graduating auto mechanics students	58	.327**
Auto mechanics	32	.161

*p <.05.

**p <.01.

The low AAMDAT group reliabilities and limited ranges can account partially for these low correlations. A compounding factor is the questionable validity of peer nominations as a measure of auditory diagnostic ability. The assumption was that students and mechanics would be knowledgeable about the auditory diagnostic ability of their peers. To date, the peer nomination technique has been used primarily for evaluating more complex general factors such as leadership ability. Only further study will validate this technique as a good intermediate measure of specific dimensions of sensory achievement.

Although two of the three correlation coefficients were found to be statistically significant they are not of the magnitude to lend full acceptance to the hypothesis. Therefore the concurrent validity of the AAMDAT, and thus Hypothesis III, is only partially supported. However, since the AAMDAT is known to have low reliabilities for each sub-group it could be expected that these correlations would increase significantly with improvement of the AAMDAT.

Research Hypothesis IV

The complete rotated six factor analysis on the AAMDAT may be found in Appendix H. Those test items having a loading of .300 or more were considered significant for this study and are presented in Table 7. An evaluation of the common underlying factor of these items in factor one, two, and three was undertaken.

The stems, distractors, and recordings for the items loading high in factor one were carefully studied by this investigator and several people from other fields. The conclusion was that the common element for these items was the fact that these malfunctions made very definite sounds that were separable from the other simultaneous sounds of the running automobile. Factor one was considered a basic experience factor.

TABLE 7

AAMDAT ITEMS WITH LOADINGS OF .300 OR OVER FOR FACTORS ONE THROUGH SIX

Factor 1		Factor 2		Factor 3		Factor 4		Factor 5		Factor 6	
Items	Loading	Items	Loading	Items	Loading	Items	Loading	Items	Loading	Items	Loading
2	.482	3	-.402	3	.425	6	.416	9	-.334	11	.451
4	.563	21	-.436	34	.440	8	.371	13	-.435	12	-.255
6	.531	26	-.410	39	.396	23	.401	22	-.400	19	-.383
8	.398	35	-.484	42	.430	28	.446	26	-.319	28	.398
14	.442	37	-.589	43	.531	45	.460	39	.310		
16	.331										
29	.436										
30	.462										
34	.468										
42	.400										
43	.548										

The consensus on the identification of factor two was that these malfunctions produced more complex sounds that were imbedded in the total automobile noise. In an attempt to psychologically describe the auditory discrimination needed for these more complex items it was suggested that one of the auditory aptitude sub-test results would correlate highly with these items. The Hidden Tunes Test and the Tonal Memory Test seemed to most closely resemble the demands of this second factor. A correlation coefficient of .179 between the Hidden Tunes Test and questions loading on factor two was found. More significantly a correlation of .288 for the Tonal Memory to factor two questions was computed for the automotive mechanics students. With the AAMDAT in effect becoming a five question test for this factor and with its low reliability the .288 correlation is felt to be significant. Factor two was identified as a subtle tonal memory factor.

The third factor consisted of items that were believed to contain a rhythm factor. The correlation of the results on items in factor three to the results on the Rhythm Discrimination Test was computed. The resulting coefficient of .344 gave support to the consensus that factor three was a rhythm factor.

A meaningful psychological interpretation of the remaining three factors was not possible. No concensus on the underlying dimension could be found. It should be noted also that the interpretation of the first three factors is quite tentative. Only with replication can confidence be placed in these psychological interpretations.

With the existence and tentative identification of several dimensions of auditory diagnostic ability Hypothesis IV was accepted.

Research Hypothesis V

The correlations between performance on the nine auditory aptitude sub-tests and the AAMDAT achievement for the first year and graduating auto mechanics students are presented in Table 8. These correlation coefficients range from .052 to .323. Although these correlations are not very large, the size of the sample is sufficient to make the Tonal Memory Test ($r = .279$) and the Hidden Tunes Test ($r = .323$) significantly related to AAMDAT performance beyond the .01 level.

There were serious restrictions on the probability of obtaining significant correlations between the AAMDAT and the Auditory Aptitude Battery for the automotive students. This was due to the low reliabilities which

TABLE 8

CORRELATIONS OF FIRST YEAR AND GRADUATING AUTO MECHANICS STUDENTS PERFORMANCE ON AUDITORY APTITUDE SUB-TESTS TO AAMDAT ACHIEVEMENT

Sub-Tests	Correlation	N
Pitch discrimination	.055	157
Loudness discrimination	.052	157
Rhythm discrimination	.121	157
Time discrimination	.074	154
Timbre discrimination	.066	154
Tonal memory	.279*	153
Copying behind test	.102	144
Dot perception test	.142	145
Hidden tunes test	.323*	128

*p<.01.

result from the limited range in performance on the AAMDAT of this homogenous sample.

Assume the AAMDAT and aptitude tests were revised to an infinite length (thus having a perfect reliability). Their correlation coefficients would then be expected to increase. An estimate of the maximum correlation coefficients that could be achieved if these measures were perfectly reliable can be made. The coefficients corrected for attenuation are presented in Table 9. The Hidden Tunes Test correlation (r = .469) and the Tonal

TABLE 9

CORRECTIONS FOR ATTENUATION FOR CORRELATIONS OF FIRST YEAR AND GRADUATING AUTO MECHANICS STUDENTS PERFORMANCE ON AUDITORY APTITUDE SUB-TESTS TO AAMDAT ACHIEVEMENT

Sub-Tests	Correlation	Corrected for Attenuation
Pitch discrimination	.055	.074
Loudness discrimination	.052	.087
Rhythm discrimination	.121	.154
Time discrimination	.074	.111
Timbre discrimination	.066	.094
Tonal memory	.279	.364**
Copying behind test	.102	.107
Dot perception test	.142	.179*
Hidden tunes test	.323	.469**

*p <.05.

**p <.001.

Memory Test (r = .364) theoretically becomes significant beyond the .001 level. The Dot Perception Test (r = .179) becomes significant beyond the .005 level. This correction is theoretical and is not useful in prediction equations. It does, however, suggest the upper limits of what could be expected by improving the reliabilities of both instruments.

A more realistic estimate of what correlations could be expected is to correct for the effects of the range restriction on the AAMDAT. Reduction of the range reduces the correlation coefficients (Ghiselli, 1964, p. 362). If the AAMDAT were administered to a more heterogeneous population the range should increase greatly. Estimated correlations of aptitude to normally distributed AAMDAT scores, instead of the present leptokurtic distribution, would increase. These correlation coefficients more closely represent the predictive potential of the aptitude battery for auditory diagnostic achievement among auto mechanics students and are presented in Table 10.

An estimate of the overall predictive strength of the auditory aptitude battery was then made. This was done for achievement on the several measures by the graduating auto mechanics students only. The multiple correlation of the nine predictor variables to AAMDAT achievement was .410 ($p<.001$).

TABLE 10

CORRECTION FOR RESTRICTION ON AAMDAT RANGE ON CORRELATIONS TO AUDITORY APTITUDE SUB-TESTS FOR FIRST YEAR AND GRADUATING AUTO MECHANICS STUDENTS

Sub-Tests	Correlation	Corrected Correlation	N
Pitch discrimination	.055	.075	157
Loudness discrimination	.052	.072	157
Rhythm discrimination	.121	.167*	157
Time discrimination	.074	.103	154
Timbre discrimination	.066	.092	154
Tonal memory	.279**	.375***	153
Copying behind test	.102	.141	144
Dot perception test	.142	.196*	145
Hidden tunes test	.323**	.429***	128

*p <.05.

**p <.01.

***p <.001.

Again it should be pointed out that with an increased reliability a significant increase in the correlation coefficient would be expected. For this reason, the already encouraging .410 multiple correlation of auditory aptitude to auditory diagnostic ability should lend support for the rejection of Hypothesis VII and the encouragement of further research in establishing the true predictive value of these aptitude tests.

7

The correlation matrix of the auditory aptitude sub-tests and the AAMDAT is presented in Table 11.

Research Hypothesis VI

The dimension being studied through the evaluation of this hypothesis was the independence of these two measures. The belief was that auditory diagnostic achievement is independent of cognitive paper and pencil test achievement in the field of auto mechanics.

The test results of those graduating auto mechanics students who took both the AAMDAT and the paper and pencil Auto Mechanics Achievement Test were correlated. For these sixty-one subjects a correlation coefficient of .249 was obtained.

This correlation coefficient would probably be increased if the AAMDAT reliability for this sub-group were increased. This is demonstrated in the increased correlation coefficient of the shortened AAMDAT to the paper and pencil test results. Table 12 contains these comparative increases. As the odd-even AAMDAT reliability went from .235 to .333 the AAMDAT to paper and pencil

TABLE 11

CORRELATION MATRIX OF AUDITORY APTITUDE AND AAMDAT ACHIEVEMENT BY THE SIXTY-SEVEN (67) GRADUATING AUTO MECHANICS STUDENTS

Standardized Regression Coefficients		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(c)
-.183	(1) Pitch Discrimination										
.768	(2) Loudness Discrimination	.291									
-.152	(3) Rhythm Discrimination	.375	.421								
.109	(4) Time Discrimination	.463	.468	.335							
.684	(5) Timbre Discrimination	.307	.410	.265	.371						
.335	(6) Tonal Memory	.334	.242	.192	.348	.238					
-.516	(7) Copying Behind	.185	.324	.331	.315	.411	.091				
-.108	(8) Dot Perception	.315	.177	.121	.381	.389	.397	.467			
-.130	(9) Hidden Tunes	.130	-.014	-.159	.099	.303	.374	-.131	.487		
	(c) AAMDAT	-.097	.051	-.138	.023	.082	.288	-.036	.054	.221	

test correlation went from .249 to .263. With a correction for range restriction on the AAMDAT the correlation between the AAMDAT and the paper and pencil test would be expected to increase from .249 to .346. Even with this increase in the AAMDAT range it is obvious from the relatively low initial correlation that the AAMDAT is partially measuring a dimension not being measured by the paper and pencil test.

The acceptance of Hypothesis VI lends further support to the need for measures of achievement in the sensory dimensions of performance.

TABLE 12

CORRELATION OF THE TOTAL AND SHORTENED AAMDAT TO THE PAPER AND PENCIL AUTO MECHANICS ACHIEVEMENT TEST RESULTS FOR THE GRADUATING AUTO MECHANICS STUDENTS

	N	Odd-even Reliability	Correlation to Paper and Pencil Test
Total AAMDAT	61	.235	.249
Shortened AAMDAT	61	.333	.263

CHAPTER VI

SUMMARY

Restatement of the Purpose of the Study

It was the purpose of this study to develop and validate a test to measure the ability to diagnose malfunctions in automobiles through the auditory sense.

Results and Conclusions

Auditory diagnostic achievement as measured by the AAMDAT was found to have a reliability of .71 for the total group (N = 269). The reliability for the no experience group (N = 67) was .335, .433 for the first year auto mechanic students (N = 91), .436 for the graduating second year auto mechanic students (N = 67), and .252 for the auto mechanics (N = 44). In its present form the AAMDAT cannot be considered a sufficiently reliable to make fine discriminations in auditory diagnostic ability between individuals within any one of the groups in this study. The belief that a careful revision of the AAMDAT would result in an instrument with this discriminating ability was supported in the analysis and discussion of the data.

The construct validity of the AAMDAT was tested and supported through the theoretical construct that auditory diagnostic ability increases with experience. The auto mechanics achieved significantly higher (P<.0005) than the graduating auto mechanics students, whose achievement was in turn significantly higher (P<.01) than the first year auto mechanics students, whose achievement was significantly higher (P<.0005) than the no experience group. An analysis of variance computation of the same data produced an F value significant beyond the .0001 level.

The concurrent validity of the AAMDAT, which was evaluated by correlating AAMDAT achievement to peer nominations on the same dimension, was partially supported. These independent measures of auditory diagnostic ability correlated .256 for the first year auto mechanics students, .327 for the graduating auto mechanis students, and .161 for the auto mechanics. These low correlations may be partially explained by the limited range and reliability on the AAMDAT, as well as the questionable validity of the peer nomination technique as an intermediate criterion.

A principle axes factor analysis on the AAMDAT items produced several groups of items having high intercorrelations. These independent dimensions of auditory diagnostic ability were reviewed in order that they be identified in psychological terms. Factor one was identified as a basic experience factor, factor two a subtle tonal memory factor, and factor three a rhythm factor. The weaker remaining three factors were left unidentified.

The potential of the Auditory Aptitude Test Battery as a predictor of auditory diagnostic achievement was revealed in the multiple correlation of the nine predictor tests to the AAMDAT. A multiple correlation of .41 (P<.0001) between these measures was achieved for the graduating auto mechanics students. A revised AAMDAT with an increased range and reliability should significantly increase the predictive potential of the Auditory Aptitude Battery.

The independence of AAMDAT and paper and pencil auto mechanics test achievement was supported. The graduating auto mechanics students results on these two measures had a .249 correlation.

Implications for Further Research

1. The most obvious implication for further research is to use the item analysis data to revise the AAMDAT. A much larger sample should then be tested to establish comparative norms.

2. The support this study gave to the independence of the performance and cognitive test suggests a greater need for performance testing. This would be primarily in areas where sensory discriminations are an important part of the criterion.

3. The validity of the peer nomination technique and other intermediate criteria of success in sensory achievement would assist in validating newly developed performance tests.

4. Further research on the relationship of auditory aptitude and auditory achievement as it relates to occupational success is needed.

5. Many of the sensory dimensions that are difficult to test and yet are an important part of an ultimate criterion, are also difficult dimensions to teach systematically. For the most part, auditory diagnostic ability is taught on a hit or miss basis in automotive mechanics programs. In this effort to evaluate achievement in this dimension of auto mechanics a high quality binaural test tape was developed. This same tape could easily be converted into a training instrument. Thus, a student in training could receive the equivalence of five years of on the job auditory diagnostic experience in a few hours through headsets and a carefully prepared

training tape. It is possible that research concerned with developing instructional materials in these more difficult areas could do well by taking an evaluation approach to help provide instructional answers.

REFERENCES

Adkins, Dorothy, *Construction and analysis of achievement tests*. Washington, D. C.: U.S. Government Printing Office, 1947.

American Psychological Association, *Standards for educational and psychological tests and manuals*. Washington, D. C., 1966.

Baldwin, T. S., *Achievement test for automotive mechanics*. Achievement Measures Project, University of Illinois, Urbana, Ill., 1968. Office of Education Grant No. OEG 2-6-000517-8585.

Bechtoldt, H. P., Problems in establishing criterion measures, *Personnel research and test development in the bureau of naval personnel* (D. B. Stuit, Ed.). Princeton, N. J.: Princeton University Press, 1949, Chapter 19.

Crouse, W. H., *Automotive electrical equipment*. New York: McGraw-Hill Book Company, 1955.

____________., *Automotive mechanics*. New York: McGraw-Hill Book Company, 1960.

Close, P. and Ireland, G., Alterations in the pure tone threshold following changes in both absolute and differential pressures upon the ear. *USN medical school report - project number MR00513-1002*, 1960.

Davis, H., *Hearing and deafness*. New York: Murray Hill Books, Inc., 1947.

DuBois, P. H., *An introduction to psychological statistics*. New York: Harper and Row, Publishers, 1965.

Evans, R., *A suggested use of sequential analysis in performance testing*. Urbana, Illinois: University of Illinois, 1953.

Fleishman, E. A., and Friedman, M. P., *Some standardized tests of auditory-perceptual abilities*. Lackland Air Force Base, Texas: 1957. Research Report AFPTRC-TN-57-132, ASTIA Document No. AD 146405.

Fogel, L. J., *Biotechnology: concepts and applications*. Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1963.

Frederiksen, N., Proficiency Tests for Training Evaluation, *Training research and education* (R. Glaser, Ed.) New York: John Wiley and Sons, Inc., 1965, 323-346.

Gagne, R. M., and Fleishman, E. A., *Psychology and human performance*. New York: Henry Holt and Company, 1959.

Ghiselli, E. E., *Theory of psychological measurement*. New York: McGraw-Hill Book Company, 1964.

Glanzer, M., *Diagnostic (trouble-shooting) skills and their evaluation*. A paper presented at the 13th Congress of the International Association of Applied Psychology on April 12, 1958.

Grey, T., Equipment revolution fueled by Ford, *Motor age*, 1966-67.

Gruber, A., Sensory alternation and performance in a vigilance task, *Human factors*. New York: Pergamon Press, 1964, 6 (1), 3-12.

Hoehn, A. J. and Lumsdaine, A. A., *Design and use of job aids for communicating technical information*. Air Force Personnel and Training Research Center, January, 1958. Technical Report AFPTRC-TR-58-7. ASTIA Doc. No. AD 152109.

Hollander, E. P., The friendship factor in peer nominations. *Personnel psychologist*, 1956, 9:435-447.

Karlin, J. E., A factoral study of the auditory function. *Psychometria*, 1942, 7, 251-279.

Kekcheer, K. Factors reducing the activity of the visual and auditory organs. Izv. Akad. Pedag. Nauk.-RSFSR, 1947, 8, A6-S1.

Lichte, W. H., Attributes of complex tones, Journal of experimental psychology, 1941, 28, 455-480.

Lumsdaine, A. A., Experimental research on instructional devices and materials, Training research in education (R. Glaser, Ed.). New York: John Wiley and Sons, Inc., 1965, 247-295.

Melton, A. A., and Cowles, H. N., Implications for the air force, A preliminary report on the development of a functional knowledge of proficiency of radar mechanics - research bulletin 52-30. San Antonio, Texas: Human Resources Research Center, Lackland Air Force Base, 1952.

McCormick, E. J., Human factors engineering. New York: McGraw-Hill Book Company, 1957.

Moore, Maxine R., A proposed taxonomy of the perceptual domain and some suggested applications. Educational Testing Service, Test Development Report TDR-67-3. Princeton, N.J., 1967.

McGrath, J. J., Performance sharing in an audio-visual viglance task, Human factors, 1965, 5 (2), 141-153.

Mursell, J., The third mental measurements yearbook (O. K. Buros, Ed.). New Brunswick, N. J.: Rutgers University Press, 1949, p. 177.

Saupe, J., Trouble shooting electronic equipment. Urbana, Illinois: University of Illinois, 1954.

Seashore, C. E., The psychology of musical talent. New York: Silver, Burdett and Company, 1919.

______________., Manual of instructions and interpretations for measures of musical talent. New York: Columbia Graphphone Company, 1919.

Stander, N. E., The assessment of trade and technical education courses: the use of instructor and peer ratings as intermediate criteria of curricula effectiveness, The development of achievement measures for trade and technical education. Raleigh, North Carolina: Office of Education grant number OEG-2-6-000517-0585, August, 1966.

Ware, J. R., Effects of intelligence on signal detection in visual and auditory monitoring, Perceptual motor skills. 1961, 13, 98-102.

Welch, B., Augmenting auto-diagnosis with audiotapes, School shop. April, 1968, 88.

Wherry, R. J. and Fryer, D. H., Buddy ratings: popularity contest or leadership criteria? Personnel psychologist, 1949, 2:147-159.

Wing, H. D., The fourth mental measurements yearbook (O. K. Buros, Ed.). Highland Park, N. J.: The Gryphon Press, 1953, 229-230.

Wolins, L., "The validity of peer ratings as a function of rater characteristics and methods of scoring." Unpublished Doctoral Dissertation. The Ohio State University, 1956.

Wood, Dorothy Adkins, Test construction. Columbus, Ohio: Charles E. Merrill Books, Inc., 1960.

APPENDIX A

PROSPECTIVE SOUNDS FOR THE AAMDAT

Prospective Sounds for the Auditory Automotive Mechanics Diagnostic Achievement Test

Systems with potential malfunctions ranked in order of importance

A. Engine (mechanical)

1. excessive connecting bearing clearance
2. crankshaft knock - worn main bearings
3. excessive valve clearance
4. defective hydraulic valve lifters
5. piston slap
6. piston pin (wrist pin) noise
7. dry rocker arms
8. burnt or non-seating valves
9. estimate of engine RPM's
10. crankshaft knock - worn end-thrust bearings
11. insufficient stem lubrication
12. piston ring noise
13. timing chain or gear noise
14. broken push rods
15. hot engine
16. worn camshaft or camshaft bearings
17. foreign particles embedded in piston (hitting cylinder head)
18. blown head gasket
19. loose or broken flywheel (automatic transmission)
20. defective engine mountings

B. Engine (electrical)

1. generator bearing
2. spark knock
3. chattering solenoid plunger
4. slow disengaging starter pinion
5. high voltage leaks in the secondary ignition system
6. spark plug misfiring
7. abnormal distributor noise
8. engine noise in the radio
9. dry generator and fan belt
10. late and early ignition timing

11. slow engaging starter bendix
12. turn signal flasher

C. Engine (fuel)

1. carburetor air leak
2. fuel pump; worn or broken rocker arm
3. removing fuel tank cap with vent restricted
4. carburetor; low speed and idle circuit, rev up to 900 RPM's - will increase evenly if circuit operates correctly
5. carburetor; high-speed circuit, if running 1200 RPM's and air horn slowly covered with the hand, the engine should speed up if operating correctly
6. fuel line thumping
7. vacuum pump with hose restricted
8. intake manifold leaking
9. detonation (low octane fuel)
10. air cleaner loose - rattle
11. setting carburetor idel mixture screws (change in RPM's and smoothness of engine)

D. Engine (cooling)

1. defective water pump
2. slipping fan belt
3. fan blades striking radiator shroud
4. escaping steam from a hot engine
5. heater temperature control valve (hoses crossed)

E. Chassis, Suspension, and Tires

1. shock absorbers - loose
2. ball joints
3. tire with a flat spot
4. power steering pump bearings
5. squaling tires on turns
6. squeaking springs
7. fluid low in power steering pump
8. defective front wheel bearings
9. cracked mounting lug hole in wheel
10. control arm bushings
11. shock absorbers - grommets worn out

F. Transmission and Drive System

1. defective universal joint
2. defective ring and pinion
3. defective release bearing in a standard transmission
4. broken transmission teeth
5. rought or damaged wheel bearing
6. defective rear axle bearing
7. loose differential carrier bearing
8. slipping clutch
9. differential ring and pinion not matched (adjusted)
10. defective rear bearing in transmission (automatic and standard)
11. warped drive shaft
12. transmission or rear lubrication low
13. worn bevel and pinion gears

G. Braking System

1. worn or warped linings
2. vacuum leaks in power brake unit
3. loose flang plate bolts
4. warped brake drum
5. metal to metal contact (shoe to drum contact)
6. hard lining
7. temporary engine acceleration when power brakes are applied
8. dirt or gravel inside drum
9. brake squeak due to improper seating

H. Auxiliary or Miscellaneous Systems

1. speedometer cable noise
2. vacuum leak from windshied wiper hose
3. defective heater motor
4. exhaust leaks and rattles
5. body squeaks and rattles
6. loose door jamb striker plates
7. wind noises around doors, glasses, moldings
8. dry weather seal around doors and body
9. improperly ounted wheel cover (squeaks)

APPENDIX B

RECORDING AND TRANSMITTING EQUIPMENT SPECIFICATIONS

Recording and Transmitting Equipment Specifications

Tape Recorder

Ampex AG-44-2 Recorder/Producer;

1/4" wide tape; two heads (tracks); speeds

7 1/2 - 15 ips; portable mounting

Output Amplifier

Electrovoice #1244 stereo amplifier

65 watt

Microphones

Norelco #D202E dynamic microphone

Headsets

Koss Pro-4A stereo headsets

Tape

Scotch #201, 1 1/2 mil. acetate recording tape

APPENDIX C

AAMDAT SCRIPT

Script for the Auditory Automotive Mechanics Diagnostic Achievement Test

This is a test designed to measure the ability of mechanics to diagnose malfunctions in automobiles through the use of their trained ears.

For this test, automobiles with malfunctions have been recorded with high fidelity equipment. Your job will be to identify what malfunctions are present in these recordings.

For each question you will be given a certain amount of information that may help in making correct responses. Some of this information will include automobile year, make, and engine displacement. In most instances automobiles with small V.8. engines, automatic transmissions, power steering, and power brakes have been used. The alternatives for each question will be given on the recording, as well as on your printed test booklets.

After you have been given the introductory information for a question, and the alternatives have been presented, you will hear the actual automobile. While listening to the automobile, decide which alternative (A, B, C, or D) you believe to be correct. Darken in the corresponding space for that question on the answer sheet.

Let's try a practice question before we actually begin the test. Open your test booklet to Page 1. Have your answer sheet and pencil ready. You are to mark the correct answer in the space for question 1 on your answer sheet.

Practice Question Number 1

You will hear a V.8 engine starting in this recording. Your job is to identify the manufacturer of the car.

A. General Motors Corporation
B. Ford Motor Company
C. Chrysler Motor Corporation
D. American Motor Corporation

The car you just heard was a 1967 Plymouth equipped with a 273 V.8 engine. You should have marked letter "C" on question one of your answer sheet.

We will now get ready to start the test. Make sure you have an answer sheet, test booklet, and pencil on your desk. Also make sure that your head-sets are positioned comfortably on your head. Answer every question on the test, even if you have to guess. If you have any questions, please raise your hand now. Open your test booklet to Page 2. This first series of questions will deal with a 1967 Chevrolet that is equipped with a 283 cubic inch V.8 engine.

Question Number 2

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Question Number 22

You have now completed all the questions dealing with Chevrolets. We will take a few minutes break. Put your answer sheet in your test booklet and then close it. You will be told when the second half of the test will begin. Please do not discuss the test with your neighbors. Stand and stretch if you would like, and take your headsets off.

PART II

This next series of questions will deal primarily with a 1967 Ford that is equipped with a 289 cubic inch V.8 engine.

Question Number 23

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Question Number 38

You have now completed the Ford questions. We will move on to the last part of this test.

PART III

This last series of questions will deal with a 1967 Plymouth that is equipped with a 273 cubic inch V.8 engine.

Question Number 39

•
•
•
•

Question Number 45

You have now completed the auditory achievement test. Please make sure your name, and the name of your school or place of emeployment are on your answer sheet. Erase any stray marks that may be on your answer sheet. Place all test materials in your envelope. Thank you for your cooperation. You may now take off your headsets.

NOTE: This test was developed under the U.S. Office of Education Grant Number OEG 2-6-00517 Vocational Education Act of 1963, Pl. 88-210. Through the Office of Education limited copyright is placed on certain research findings that would lose their effectiveness if their distribution was not controlled. For this reason the specific test items of the AAMDAT do not appear in this paper.

APPENDIX D

SOME STANDARDIZED TESTS OF AUDITORY-PERCEPTUAL ABILITIES

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SOME STANDARDIZED TESTS OF AUDITORY-PERCEPTUAL ABILITIES

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SOME STANDARDIZED TESTS
OF AUDITORY-PERCEPTUAL ABILITIES*

This report describes a number of auditory-perceptual tests which have been developed in the Operator Laboratory, Air Force Personnel and Training Research Center. The original impetus for developing these tests was an interest in the skill components underlying proficiency in radio-telegraphy. However, it is felt that these measures may have more general utility for other skills where auditory discrimination is critical.

The purpose of this report is to acquaint other research workers with these tests and with other auditory-perceptual tests available in this laboratory. In a sense, this report may serve as a preliminary manual for certain of these tests which have not been described elsewhere. No claim is made that these data are systematic or complete. A complete study of these measures was beyond the scope of the original studies for which the tests were developed. However, the available data are summarized here for the use of other investigators interested in related problems. It is also felt that the development of auditory-perceptual tests involves some unique test construction and psychometric problems, and the author's experiences may be of some value.

All the tests are recorded on high-fidelity tape, complete with narration, practice examples, and demonstration. The auditory signals on the tapes were recorded from various sources. The tests will be described in turn.

THE COPYING BEHIND TEST

Description

This test was designed to provide a straightforward measure of sheer speed of auditory perception. The examinee hears groups of numbers called out in rapid succession (e.g., 4 - 2 - 4 - 1 - 3). His task is to mark under the proper alternative (numbered 1 to 5) on an IBM answer sheet, going from item to item in turn, trying to keep up with the pace set by the narrator.

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*Research completed in July 1957; draft manuscript released by authors on 30 September 1957; final manuscript received for publication on 13 November 1957.

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1. Internal characteristics. The test contains 30 unscored practice items and 240 scored items presented in a continuous session. The pace at which the narrator calls out successive numbers is constant within groups of 60 successive numbers (items). Pace increases every 60 items. After every 5 numbers, there is a short pause to assist examinees in keeping their place on the answer sheet. After every 15 items, the narrator reminds the subject of the next item number. The order of the numbers called out was determined from a table of random numbers.

2. Administration. Total administration time required is 7 minutes. Following are the complete directions, sample items and test items as recorded on the tape.

> This is a test of how fast you can react to a series of signals. Look at your answer sheet. You will notice that each item has five choices numbered 1, 2, 3, 4, and 5. Now on the test you will hear a series of numbers called out. These numbers will indicate which choice to fill in on your answer sheet next to each item. These numbers will be called in rapid succession, and your job is to go from item to item as rapidly as you can, marking in one choice for each item. You will hear a series of numbers called out to you. Your job is simply to mark your answer sheet as quickly as you hear each number. For example, you will hear a series such as this: 4 - 1 - 3 - 2 1 5. Your job is simply to go right down your answer sheet, starting with Item 1, and mark in the right numbers in the order in which you hear them. Now you will have to listen closely so that you will not get behind. To help you keep your place, there will be a short pause after every 5 numbers. This will also help you catch up to the next group of numbers in case you have to skip some.
>
> Let's have a little practice at this. Start at Item 1 and go down through Item 20, making only one mark to the five choices for each item. The correct choice will, of course, be the number I called out to you. In order to help you keep up with the numbers in the right order, make only a light mark as you go from item to item. Do not try to fill in the slots as this will only slow you up.
>
> All right, get ready for the practice session. Start at Item 1 and go from item to item on your answer sheet, marking in the numbers in the order they are called out. Ready, GO!

(Numbers are called out.)

Now check your answers. The correct choices, starting with Item 1, were 2 - 2 - 3 - 4 - 2, 4 - 2 - 3 - 3 - 4, 4 - 5 - 3 - 3 - 5. Beginning with Item 16 you should have marked 2 - 3 - 2 - 3 - 4, 4 - 2 - 5 - 1 - 5, 4 - 5 - 4 - 3 - 4.

As you can see, sometimes it is pretty hard to keep up. At any rate, do your best and do not get discouraged as you can do some catching up on some later items. The speed will be slower at first, but will get a little faster throughout the test.

Are there any questions? All right, begin at Item 31 and mark as quickly as you can. READY! GO!

5 - 1 - 3 - 3 - 5   5 - 3 - 4 - 4 - 5   1 - 5 - 2 - 5 - 1

Go on to Item 46.

4 - 1 - 3 - 4 - 4   1 - 3 - 5 - 1 - 5   4 - 1 - 1 - 5 - 2

Go on to Item 61.

3 - 2 - 5 - 1 - 4   4 - 3 - 1 - 3 - 4   3 - 5 - 3 - 4 - 2

Go on to Item 76.

4 - 2 - 4 - 3 - 3   3 - 4 - 4 - 2 - 1   1 - 1 - 5 - 1 - 4

Go on to Item 91.

(Pace increases.)

2 - 2 - 2 - 3 - 3   3 - 2 - 3 - 2 - 3   4 - 4 - 4 - 5 - 4

Go on to Item 106.

4 - 4 - 2 - 4 - 1   5 - 3 - 1 - 4 - 5   4 - 1 - 2 - 1 - 3

Go on to Item 121.

5 - 5 - 3 - 2 - 3   1 - 3 - 4 - 5 - 1   4 - 5 - 5 - 3 - 4

Go on to Item 136.

1 - 2 - 4 - 1 - 1   1 - 3 - 5 - 4 - 1   4 - 4 - 4 - 4 - 2

Now turn your answer sheet over quickly.

Go on to Item 151.

(Pace increases.)

5 - 2 - 5 - 1 - 2   3 - 2 - 3 - 4 - 3   3 - 5 - 5 - 3 - 3

Go on to Item 166.

1 - 2 - 4 - 1 - 3   5 - 5 - 3 - 1 - 1   5 - 1 - 1 - 1 - 3

Go on to Item 181.

5 - 5 - 4 - 2 - 1   1 - 2 - 4 - 5 - 1   2 - 3 - 3 - 5 - 1

Go on to Item 196.

2 - 5 - 4 - 3 - 4   4 - 2 - 3 - 1 - 3   2 - 2 - 1 - 1 - 3

Go on to Item 211.

(Pace increases.)

1 - 4 - 2 - 3 - 2   1 - 3 - 1 - 5 - 5   2 - 2 - 1 - 5 - 3

Go on to Item 226.

3 - 2 - 2 - 5 - 1   4 - 4 - 5 - 4 - 4   4 - 3 - 4 - 4 - 4

Go on to Item 241

3 - 5 - 2 - 1 - 2   2 - 1 - 2 - 3 - 2   4 - 5 - 4 - 3 - 5

Go on to Item 256.

4 - 1 - 1 - 1 - 4   5 - 3 - 5 - 4 - 2   4 - 3 - 5 - 4 - 4

That is the end of the test.

The examinee is not required to fully blacken in each slot on the answer sheet; otherwise, he could not possibly keep up with the test. For hand scoring, using a stencil key, this is not serious. For machine scoring, the scorer or some designated individual must blacken in fully the spaces indicated by the examinee's marks.

3. Scoring--number right. The scoring key is provided in Appendix A.

Statistical Results

Data presented are based on 388 entering radio operator trainees tested at Keesler Air Force Base in 1955. These airmen had been selected on the basis of scores on the Radio Operator Aptitude Index.[1]

1. Distribution statistics. The distribution of scores on this test is indicated by a mean of 127.37 and a standard deviation of 28.82.

2. Reliability. The odd-even split-half reliability is .98. Due to the highly speeded nature of the test, this coefficient is not strictly appropriate, and is undoubtedly inflated. However, it is the only estimate available.

3. Difficulty. The mean proportion of items answered correctly is .53. Since this is based on a sample of trainees already selected on the basis of the ROAI (which includes the Auditory Army Radio Code test), the test is probably even more difficult for the general airman population.

During the test, the pace at which the numbers were called out was increased progressively, at stages. This occurred after every 60 items. Table 1 presents the mean correct responses for each of these four part scores. It is apparent that mean scores decrease progressively at each increase in speed of presentation. Thus, the particular step increases in pace, originally decided upon arbitrarily, did produce a discriminable increase in difficulty at each stage.

---

[1] Correlations and validity coefficients presented for this test and the subsequent tests described have been corrected for possible range restriction from prior selection.

Table 1

Part Scores on the Copying Behind Test
for Four Successive Increases in Signal Speed

($\underline{N}$ = 388)

Part	Item Number[a]	Presentation Time	M[b]	SD
1	31 - 90	35.5 sec.	48.40	10.63
2	91 - 150	31.5 sec.	37.87	10.82
3	151 - 210	24.5 sec.	23.28	9.38
4	211 - 270	20.0 sec.	18.29	6.49

---

[a] First 30 items are practice.

[b] Number correct out of 60.

4. Intercorrelations with other measures. Table 2 presents correlations between the scores on Copying Behind and other measures from the Airman Classification Battery AC-1A. Correlations with part scores as well as with total scores on the tests are included.

It is clear that there is some overlap with the numerical tests. Apparently, apprehending and/or finding a particular number when it is called out contributes to this. Table 3, which presents intercorrelations with other auditory tests, indicates the Copying Behind test correlates highly with certain kinds of auditory measures. That the test does not measure simple speed of answer-sheet marking is indicated by the low correlation with a test called Marking Accuracy test. This latter test is the visual counterpart of the auditory Copying Behind. The examinee is required simply to mark an IBM answer sheet under the circled letter, going from item to item as rapidly as possible. The low r of .28 between the two tests confirms the relative independence of the auditory and visual perceptual functions.

5. Factorial composition. In a recent factor analysis of auditory-perceptual and other tests, Fleishman, Roberts, and Friedman (3) showed that Copying Behind loaded mainly on an Auditory Perceptual Speed

factor (loading = .54). Secondary loadings for this test were on the Auditory Rhythm Discrimination factor (loading = .32), and Speed of Closure factor (loading = .31).

Table 2

Correlations Between Total and Part Scores of the Copying Behind Test with Airman Classification Battery Variables

(N = 388)

Variable	Parts				
	1	2	3	4	Total
1 Word Knowledge	.26	.29	.28	.21	.34
2 Arithmetic Reasoning	.34	.41	.33	.32	.45
3 Dial and Table Reading	.42	.47	.35	.35	.53
4 Numerical Operators	.37	.39	.37	.29	.44
5 Aviation Information	.17	.18	.13	.14	.20
6 Background for Current Affairs	.20	.26	.21	.12	.27
7 Electrical Information	.17	.18	.15	.15	.21
8 Mechanical Principles	.12	.23	.14	.13	.21
9 General Mechanics	.23	.21	.13	.14	.23
10 Tool Functions	.05	.05	-.01	.05	.05
11 Memory for Landmarks	.27	.30	.22	.23	.33
12 Pattern Comprehension	.17	.27	.22	.23	.29

Table 3

Correlations Among the Auditory Tests

(N = 388)

Test	1	2	3	4	5	6
1 Copying Behind		.45	.45	.32	.25	.42
2 Dot Perception (Form C)			.82	.46	.33	.44
3 Code Distraction (Form B)					.30	.43
4 Hidden Tunes					.38	.18
5 Rhythm Discrimination (Form D)						.15
6 Army Radio Code Test						

6. Test validity. The test was found to have substantial validity for predicting various proficiency criteria of radio operators in training. The test correlated -.40 with the number of days required by trainees to reach a speed of 14 groups per minute in receiving Morse Code; that is, those scoring high on Copying Behind tended to take less time to achieve this subsequent level of proficiency. More complete validity data are under study by the authors.

7. Part-score studies. A number of analyses were made of the four differently speeded parts of the test. Table 2 presents the correlations of the part scores with the Airman Classification Battery variables.

Table 4 presents the intercorrelations among the part scores themselves, between these scores and the ROAI, and between these scores and a criterion of proficiency in receiving Morse Code.

Table 4

Copying Behind Part-Score Validities, Intercorrelations, and Correlations with the ROAI

(N = 388)

Part	1	2	3	4	ROAI[a]	Criterion[b]
1		.52	.36	.36	.38	-.30
2			.46	.48	.42	-.21
3				.55	.36	-.28
4					.32	-.33

---

[a] At this time, the ROAI consisted of the Army Radio Code Test (5), Word Knowledge (2), Biographical Information (1), Numerical Operations (1), and Dial & Table Reading. The weights given these tests in the ROAI composite are in the parenthesis.

[b] Number of days for radio operator trainees to reach a code speed of 14 groups per minute in receiving International Morse Code.

It is obvious that there is no systematic increase or decrease in intercorrelations with other test measures or in validity of the Copying Behind test as a function of speed of signal presentation.

THE DOT PERCEPTION TEST

A major source of difficulty in the reception of telegraphic code is the estimation of the correct numbers of dots sent in rapid succession within a signal pattern. (For an empirical demonstration of this, see Highland and Fleishman [5].) It seemed possible that the ability to make this kind of discrimination might be somewhat different from the ability to make other kinds of auditory discriminations, e. g., pitch, rhythm, etc. The Dot Perception test was constructed to examine the predictive value of a measure of this kind of function.

The original form of the Dot Perception test (4) presented a series of 50 five-signal groups, consisting of "dots" and "dashes." Each five-signal group represented a test item. The number of "dots" (one to five) varied from item to item in a randomly determined order. In each item the number of "dots" always preceded the "dashes." (Of course, in an item with five "dots," there were no "dashes.") For each item, the examinee simply marked on a standard IBM answer sheet the number of dots (1, 2, 3, 4, or 5) presented in each signal pattern. This simple procedure was followed to minimize the "learning" aspects of the test in favor of the discrimination aspects. Complete instructions for this form of the test are presented elsewhere (4).

Although this test had a high reliability (r = .95) and appreciable validity (r = .31) in predicting subsequent code speed (after 14 weeks of training), it did not add significantly to the prediction achieved by the operational Army Radio Code test. Moreover, in its original form it appeared to be too easy. There was a suspicion that some examinees were responding to the number of dots, while others simply counted the number of dashes and subtracted from five to estimate the number of dots.

Description

The present revision attempted to overcome these previous difficulties. In contrast to the earlier form of the test, in the present form the dots preceded, followed, or were interspersed with the dashes. The number of dots per item still ranged from one to five. However, the total number of dots and dashes varied from item to item. Instead of holding the total number of signals per item constant, the total time to send a signal group was held constant. This was done in the following manner. If we regard the time to send a dot signal as a standard and call this standard one "baud," then there are 3 bauds to a dash signal, and each inter-signal group space is one baud in length. In the Dot Perception test, the total number of bauds per item (signal group) was kept to either 9 or 11 bauds. Thus, the total time per signal provided little cue as to the number of dots per signal. The examinee was required to decide on the number of dots by making an intra-signal group discrimination. It was necessary to select 9 or 11 bauds in order to have sufficient degrees of freedom in constructing the signal groups to provide a range of one to five dots per signal. For example, a restriction of 9 bauds would allow only an odd number of dots per signal (e. g., . ___ ___, . . . ___, or . . . . .). Adding a dot to the first two of these signals and creating groups with two or four dots require 11 bauds. The order of presentation of the 15 different signal groups possible under this restriction was determined by using a table of random numbers.

The test signals were recorded through a system utilizing a Bohme tape-punching device. The spacing between the holes punched varies with the length of the signal-tone signal-space desired. The punched tape is then "played" through an amplifier device. For our purposes these sounds were recorded on high-fidelity magnetic tape and spliced with another tape containing the narration. This is a distinct improvement over the procedure followed in the original form of the test. In that form the signals were recorded using a standard telegraph key in conjunction with a small oscillator. The signal was then picked up through a communication receiver and fed into a tape recorder. The present system ruled out variations in pitch and unevenness of signals inherent in the earlier method. As in the earlier form of this test, the examinee listens to the signal groups (one group represents an item) and marks either a 1, 2, 3, 4, or 5 slot on his IBM answer sheet, depending on the number of dots he perceives.

1. Internal characteristics. The test contains 15 unscored practice items and 160 scored items presented in a continuous session. The pace of the signals varies at step intervals through the test. Both intra-signal group and inter-signal group speed were varied according to the schedule in Table 5. Essentially the inter-signal interval represents the time that the examinee has to mark his answer before a new group is presented. After every five signal groups (items), there is a brief pause to assist examinees in keeping their place on the answer sheet. The narrator calls out the current item number every 20 items.

2. Administration. Total administration time required is 17.5 minutes. The complete directions recorded on the tape follow:

Table 5

Part Scores on the Dot Perception Test for Eight Successive Increases in Intra-Signal and Inter-Signal Speeds

(N = 388)

Part	Item Numbers	Intra-Signal Speed[a]	Inter-Signal Speed	Mean	SD
1	16-35	12 gpm	2 sec.	12.47	3.77
2	36-55	16 gpm	4 sec.	11.22	3.90
3	56-75	16 gpm	2 sec.	9.34	3.88
4	76-95	20 gpm	4 sec.	8.94	3.69
5	96-115	20 gpm	2 sec.	8.24	3.39
6	116-135[b]	24 gpm	3 sec.	7.90	3.05
7	151-170	16 gpm	1.5 sec.	7.06	3.30
8	171-190	20 gpm	1.5 sec.	7.05	2.99

---

[a] Tone speed in groups per minute.

[b] At the end of Item 135, examinees are instructed to turn over the answer sheet and begin with Item 151 on the second side. This is to avoid the necessity of turning the sheet in the middle of a series of signals. Items 136-150, which complete the first side, are left unmarked.

May I have your attention please.

In this test you are to learn a very simple code. The code consists merely of counting the number of dots you hear in a group of signals which will consist of both dots and dashes.

Here is an example of a signal.

(Signal)

The pattern for that signal was dot dot dot dash. Here is another signal.

(Signal)

This signal was dot dash dash.

In the test your job is merely to count the number of dots in each group. Here are some more examples.

(Signal)

This signal was dot dash dash dot so there were two dots in this group.

(Signal)

There was only one dot in this group.

(Signal)

In that group there was also only one dot. All the groups will have either one, two, three, four, or five dots. Now your job is to listen closely and count the number of dots. Then on your answer sheet, fill in the space for each item that corresponds to the number of dots you hear. For example, in this pattern (signal) which contained two dots, you would blacken the space under choice 2 on your answer sheet. You follow the same procedure for each item corresponding to each group you hear.

Now we will have a little practice test. You will hear a number of these groups. Mark your answer sheet with the number of dots you hear in each group. Ready? Here is Item 1.

(Signal)

You should have blacked in choice 5 next to Item 1, since there were five dots in that group. Here is Item 2.

(Signal)

The correct answer here was choice 3 since there were three dots in that group. Now here are several more items. Item 3 (Signal). The correct answer was two dots. Item 4 (Signal). You should have marked choice 3, since there were three dots. Item 5 (Signal). The correct answer was four dots.

Are there any questions up to this point? All right, we will now have some more practice. Beginning with Item 6 go right down your answer sheet as you answer for each one. Ready? Begin. (A series of 10 signal groups.)

This is the end of this practice period. You should have finished down through Item 15. Now check the answers on your answer sheet. For Item 6 you should have marked 3. Item 7 should be marked 3. Item 8 should be marked 3, also. Item 9, 4. Item 10, 3. Item 11, 4. Item 12, 4. Item 13, 1. Item 14, 2, and Item 15, should be marked 3.

Does everyone understand what you are to do up to this point?

Now we are ready for the test. This will follow the same procedure as the practice period. Answer every item, even if you have to guess on certain ones. Since the test signals will come a little faster than the practice signals you must listen carefully and record your answer for each item promptly so that you will not get behind.

C

Beginning at Item 16, get ready for the test. All right, begin.

-....	....	-..-	.....	...-
.....	--.	....-	--.	.--.
.-..	-.-	....	.....	.--
.....	..-.	--..	-.-.	-...

Item 36

....	....-	..-.	-...	--.
.....	.....	-.-	--.	.....
.....	-....	--..	.-..	.--
-..-	....	.--.	...-	-.-.

Item 56

--..	.....	--.	....	.-..
.--	-..-	.--.	....	-.-.
....-	.....	....	..-.	...-
.....	-...	-....	--.	-.-

Item 76

-.-	...-	.-..	--.	.--
.....	--.	-.-.	-...	..-.
....-	-..-	....	.....	.....
--..	-....	.....	....	.--.

Item 96

-...	.....	..-.	.--	...-
-.-	....-	....	--.	-.-.
-...	.--.	.....	-..-	--..
....	.....	.-..	.....	--.

Item 116

....	.-..	-.-.	.....	-...
.....	--.	....	.--.	...-
..-.	-.-	.--	....-	-....
--..	-..-	.....	.....	--.

Now turn over your answer sheet and begin with Item 151.

-..-	-....	-...	--..	.....
.--	....	-.-	.....	.-..
--.	....-	.....	...-	....
.....	--.	.--.	..-.	-.-.

Item 171

-.-.	.....	-..-	.-..	-....
.....	-.-	.....	-...	....-
....	..-.	--.	.....	--.
.....	--..	.--	....	...-

3. Scoring--number right. The scoring key is presented in Appendix B.

Statistical Results

Data for the original form of this test may be found elsewhere (4). Data for the present form (Form C) were obtained from 388 entering radio operator trainees tested at Keesler Air Force Base in 1955. These airmen had been selected on the basis of scores on the Radio Operator Aptitude Index.

1. Distribution statistics. The distribution of scores on this test is indicated by a mean of 72.34 and a standard deviation of 21.99.

2. Reliability. The odd-even split-half reliability of Form C is .94. This coefficient is inflated because of the speed requirement through the test.

3. Difficulty. The proportion of items answered correctly is .45. Since this is based on a sample of trainees already selected, the test is probably more difficult for the general airman population.

It will be recalled that speed of signal presentation was increased at eight step intervals. Intra- and inter-signal speed were both increased. Table 5 shows the relative difficulties of these differently speeded portions of the test. Each of the eight intervals contains 20 items (signal groups).

It is obvious from this table that difficulty increases both as a function of the intra-signal speed and of the spacing between groups of signal (items). Fewer items are answered correctly in successive groups of 20 items throughout the test. This is true despite the advantage of

Table 6

Breakdown of Means across Intra-Signal and Inter-Signal Conditions

($\underline{N}$ = 388)

Intra-Signal Speed	Inter-Signal Speed 4 Sec.	 2 Sec.	 1.5 Sec.
12 gpm		12.47	
16 gpm	11.22	9.34	
20 gpm	8.94	8.25	7.06
24 gpm		7.90	7.05

continuous practice on these signals. In Table 6 the rearrangement provided makes this more apparent. For example, holding the time between signal groups constant at 2.0 seconds, we see a systematic decrease in the number of correct dot perceptions as the intra-signal speed is increased through the four speeds. Similarly, if we hold intra-signal speed constant at 20 groups per minute and vary the interval from 4.0 to 1.5 seconds, we find a decrease in number of correct dot perceptions. More data on these part scores are presented below.

4. Intercorrelations with other measures. Table 7 presents correlations between the scores on Dot Perception (Form C) and other measures from the Airman Classification Battery AC-1A. In general, there is little overlap between total score on Dot Perception and tests in the Airman Classification Battery.

Table 3 includes the correlation of this test with other auditory measures. It is obvious that there is considerable common variance of Dot Perception with certain other auditory measures.

5. Factorial composition. The Dot Perception (Form C) test was found by Fleishman, Roberts, and Friedman (5) to be loaded chiefly on the Auditory Rhythm Discrimination factor (loading = .58). The test also showed a secondary loading (.32) on the Auditory Perceptual Speed factor.

6. Test validity. The total test score was found to have a validity of .39 for predicting number of days required for radio operator trainees to receive Morse Code at a speed of 14 groups per minute.

Table 7

Correlations of the Dot Perception, Code Distraction, and Hidden Tunes Tests with Airman Classification Battery Variables

(N = 388)

Variables	Dot Perception	Code Distraction	Hidden Tunes
1 Word Knowledge	.28	.25	.20
2 Arithmetic Reasoning	.29	.25	.16
3 Dial and Table Reading	.31	.29	.25
4 Numerical Operations	.19	.22	.21
5 Aviation Information	.15	.16	.10
6 Background for Current Affairs	.22	.20	.14
7 Electrical Information	.18	.21	.14
8 Mechanical Principles	.19	.17	.19
9 General Mechanics	.16	.18	.03
10 Tool Functions	.07	.06	.03
11 Memory for Landmarks	.22	.19	.21
12 Pattern Comprehension	.23	.19	.27

A validity of .54 was obtained for predicting time to reach a speed of 4 groups per minute. More complete validity data are under study by the authors.

7. Part-score studies. Table 8 presents the intercorrelations among the part scores and between these scores and other auditory measures. There is some trend for the more difficult parts of the test to show a decreasing correlation with other auditory measures. This is especially true for correlations with Hidden Tunes and Rhythm Discrimination. Since these two tests are measures of an Auditory Rhythm Discrimination factor (3), it appears that the Dot Perception test becomes less a measure of this factor as the speed of signals is increased through the test. It was shown above that the total test measures both this factor and an auditory Perceptual Speed factor.

Tables 9 and 10 present validities of these part scores for predicting two criteria of Morse Code proficiency. It is apparent that the easier parts of the test are more predictive of subsequent code proficiency.

Table 8

Correlations Among Part Scores on Dot Perception and Between These Parts and Other Auditory Measures

(*N*=388)

	Part								Other Auditory Tests				
Part	1	2	3	4	5	6	7	8	Copying Behind	Hidden Tunes	Rhythm Discrimination	Army Radio Code	Code Distraction
1		.67	.65	.60	.56	.49	.51	.50	.42	.41	.35	.42	.65
2			.67	.67	.62	.49	.55	.52	.36	.40	.32	.37	.65
3				.67	.65	.54	.58	.56	.39	.37	.30	.43	.67
4					.69	.58	.61	.55	.36	.34	.28	.36	.71
5						.58	.49	.55	.32	.36	.23	.37	.70
6							.52	.49	.36	.24	.15	.35	.60
7								.54	.38	.31	.28	.40	.61
8									.31	.27	.19	.30	.64

Table 9

Validities of Differently Speeded Parts of the Dot Perception Test for Predicting "Maximum Code Speed Attained" by Radio Operator Trainees

(N = 388)

Intra-Signal Speed	Inter-Signal Speed 4 Sec.	 2 Sec.	 1.5 Sec.
12 gpm		.32	
16 gpm	.32	.31	
20 gpm	.25	.20	.25
24 gpm		.22	.21

Table 10

Validities of Differently Speeded Parts of the Dot Perception Test for Predicting "Days to Attain a Code Speed of 14 Groups per Minute"

(N = 388)

Intra-Signal Speed	Inter-Signal Speed 4 Sec.	 2 Sec.	 1.5 Sec.
12 gpm		-.45	
16 gpm	-.40	-.44	
20 gpm	-.45	-.36	-.34
24 gpm		-.34	-.37

This is consistent with the above factorial interpretation, since we have shown elsewhere (3) that code proficiency involves two auditory factors, both of which apparently are better measured by the easier portions of the test. For example, the validity of part 1 (the easiest subtest) for predicting "maximum code speed attained" is .32. The validity of the most difficult subtest is .21. The interval between signal groups appears more critical than the intra-signal speed of the signal group themselves.

THE CODE DISTRACTION TEST

Background

This test is parallel to the Dot Perception test, except that the examinee must perceive the relevant signals in the presence of distracting background noise. It would seem that a great deal of auditory perception involves this kind of function. It is certainly true in the case of radio operators and those engaged in countermeasure activities.

The Code Distraction test was developed as a measure of individual differences in the ability to ignore distracting auditory stimuli. The original form of the test has been described in detail by Fleishman and Spratte (4). The stimulus groups were of the same type as that used in the original Dot Perception test. This was to minimize learning and to emphasize the attention aspects of the task. The distraction used was taken from regular, practice code tapes which contain actual code sent at a rapid rate. Other background sounds were on the tapes, e.g., a door slamming and occasional outside traffic sounds. The examinee was required to respond (on a 5-choice IBM answer sheet) to the 150 relevant stimulus signals as on the Dot Perception test, except in this case he had to ignore the additional distraction. An attempt was made to increase the distraction through the test. At first this was done by increasing the intensity of the distraction, later by fluctuating the intensity and frequency of the distraction signals.

Results with this form revealed a reliability of .97 and a validity of .38 in predicting subsequent code speed of radio operator trainees. However, the test appeared to be as difficult as the Dot Perception test, and the correlation between these earlier forms proved to be .72. It appeared that the particular distraction introduced did not produce a measure different from that already available in Dot Perception. Either the distraction was not "distracting" or the perceptual processes involved were the same.

Description

The present form of this test, Code Distraction (Form B), parallels Form C of Dot Perception and has all the same technical advantages. The stimulus signals used were the first 120 of the 160 involved in Dot Perception. In other words, the last 40 items of Dot Perception, which were the most difficult, were dropped from Code Distraction. Along with the 120 signals, new distracting background signals were included. It was felt that these signals were much more "distracting" than those used in the original form.

The examinee was required to "receive" the relevant signal groups in turn, marking 1, 2, 3, 4 or 5 dots for each item.

1. Internal characteristics. The instructions recorded on tape for this test assume previous exposure to Dot Perception. This places a limitation on the use of this form and on the interpretation of the data now obtained from it. The tape includes demonstrations of the "relevant" signals and of the "distraction" signals separately, and then examples of both together. Five unscored practice items are presented and then 120 scored items in a continuous session. The speed of relevant signals changes every 20 items according to the same schedule as the Dot Perception test. As before, there is a brief pause after every 5 items to assist examinees in keeping their place on the answer sheet. However, there are no systematic pauses in the "distraction" signals which continue to sound throughout the test. The narrator calls out the current item number after every 20 items.

2. Administration. Total administration time of this form is 13 minutes. The complete instructions, as recorded on the tape, follow:

> You are now going to have the last part of the test. In this part you will receive the same signal patterns. Again, you will have to mark on your answer sheet the number of dots in each group. The only difference between this test and the previous one is that in this test you will hear some background signals along with these signal groups. The background signals, however, will have a different tone, so you should still be able to pick out the number of dots in the proper signal groups.
>
> You will, of course, have to concentrate a little harder on the proper groups of signals that you are supposed to receive, trying not to let the other noise interfere. To make

this clear to you, here are examples of the signals you are to receive.

(Signals)

As you can hear, these are the same kinds of signals as the ones you had before. You are merely to mark the number in each group on your answer sheet.

Now, here is an example of the signal you will have to ignore.

(Signals)

You can tell that this is a different tone from the signals you are to receive.

Now, here they are both together.

(Signals)

You can pick out the group as one with two dots, so you would mark 2 on your answer sheet. Remember, try to ignore the other signal and pick out the dots in the group with the proper tone.

Let's try a few practice groups, with the background signal in it. Mark your answer sheet, beginning with Item 1 and going through to Item 5, filling in the number of dots for each group. Ready? Listen.

(Five sets of signals)

You should have marked Item 1 as 5; Item 2 as 3; Item 3 as 5; Item 4 as 1; and Item 5 as containing 4 dots.

Are there any questions up to this point?

We are now going to have the test. Again, you must listen closely to avoid missing any signals. Mark the number of dots in each group as you hear it. Try to ignore the other signal as best you can. There will be a pause in the groups after every 10 items, but no pause in the distraction, so you must keep listening. Sometimes the distraction may stop briefly. In any case, pay attention only to the proper groups of signals.

Answer every item, and if you have to guess on certain items, do so.

Ready? Begin at Item 6 and listen for the proper signals.

(120 sets of signals, which are same
as those presented previously for
Dot Perception.)

That is the end of the test.

3. Scoring--number right. The scoring key is the same as that for Dot Perception (first 120 items in Appendix B).

Statistical Results

Data are based on 388 entering radio operator trainees at Keesler Air Force Base in 1955. These airmen had been selected on the basis of scores on the Radio Operator Aptitude Index.

1. Distribution statistics. The distribution of scores on this test is indicated by a mean of 49.70 and a standard deviation of 15.51.

2. Reliability. An odd-even split-half reliability of .92 was obtained.

3. Difficulty. The mean proportion of items answered correctly is .42. This compares with a proportion of .49 for comparable items (first 120) on Dot Perception. This indicates that the distraction was effective in reducing the number of stimulus signals perceived correctly. The effect is especially interesting, for all examinees had the benefit of practice on the Dot Perception test prior to the Code Distraction test. Again, it is to be noted that these data are based on entering radio operator trainees and that the test is probably more difficult for the general airman population.

4. Intercorrelations with other measures. Table 7 contains the correlations of total score on Code Distraction with Airman Classification Battery variables. These have been listed alongside the column of correlations for Dot Perception. From this table and the correlations with the auditory tests presented in Table 3, it is clear that Code Distraction has about the same correlation pattern as Dot Perception. The correlation between Dot Perception and Code Distraction is .82, indicating they are practically equivalent forms. Thus, it is clear that, although

mean scores may be reduced by adding distraction, individual differences in the two tests are probably a function of the same underlying ability (or abilities).

5. Factorial composition. Code Distraction has not been subjected to factor analysis study. However, its correlation with Dot Perception implies it measures the same functions, namely Auditory Rhythm Discrimination and Auditory Perceptual Speed. It had been hypothesized that Code Distraction would measure a Speed of Closure factor. This factor was defined by Thurstone as "the ability to keep a configuration in mind in spite of distraction" (6). This factor was identified in printed tests involving visual stimuli but there is some evidence this may extend to auditory tests. However, in an unpublished study the authors found correlations of Code Distraction with standard reference tests of this factor were low, indicating that these do not extend to auditory functions of this type.

6. Test validity. As would be expected from the foregoing, validity against radio code proficiency is of the same magnitude as that obtained with Dot Perception. A coefficient of .35 was obtained with the number of days required by trainees to learn code to a criterion of 14 groups per minute.

THE HIDDEN TUNES TEST

Description

The Hidden Tunes test was described originally by White (7). The examinee hears a series of short tunes presented in pairs. The first tune consists of a 3-, 4-, or 5-note melody pattern, followed after a pause by a longer melody. The examinee must determine if the second tune includes the first. The shorter tune may be part of the beginning, end, or middle of the second tune. Or, of course, it may not be included at all. The examinee indicates under a "yes" or "no" on an IBM answer sheet whether or not the simple melody was contained in the more complicated one.

According to White (7), a Hammond organ was used in making the tape recording. It was possible to keep equal intensity for all notes. The duration of each note played and the time interval between notes was controlled by a switching device and motor attached to the organ speaker.

1. Internal characteristics. The test contained four unscored practice items and 50 scored items given in a continuous session.

2. Administration. Total administration time required is 12 minutes. Following are the complete, revised directions recorded on the tape.

> Attention! This is a test of your ability to remember a tune. In the test, you will hear a short series of musical notes followed, after a slight pause, by a longer tune. Your job is to listen carefully and decide whether the second longer tune contains the first shorter one. Pay close attention to the following example and try to decide if the second tune contains the first shorter melody.
>
> (Signals)
>
> In this example, the first tune was contained in the second longer one. On the test you will have to listen carefully to the pairs of tunes and then try to decide if the second longer tune contained the first one. Then, on your answer sheet, you will mark under the "yes" if the second tune did contain the first one, and under the "no" if it did not. Let's try a little practice at this. Listen to the pair of tunes and mark under the "yes" or "no" next to Item 1 in the box marked practice items on your answer sheet.
>
> (Pair of tunes)
>
> You should have marked "no" because the first tune was not contained in the second longer one. Here are practice Items 2, 3, and 4.
>
> (Pairs of tunes)
>
> You should have marked "no" for Item 2 and "yes" for Items 3 and 4. Are there any questions?
>
> Now we are ready for the test. Sometimes the short series of notes will be at the beginning of the longer tune or it may be in the middle, or at the end--or it may not be in the longer tune at all. Remember, if you hear the first shorter tune anywhere in the longer melody, mark under the "yes." If you do not hear the shorter tune, mark under the "no." You must mark an answer for every item, and if you have to guess on certain items, do so. Mark your answers quickly so that you will not get behind. Get ready for the test. Begin with Item 1, listen carefully for the sets of tunes, and mark under

either the "yes" or "no" on your answer sheet next to the proper item.

All right, Begin!

(Tunes)

Be ready for Number 11.

(Tunes)

Be ready for Number 21.

(Tunes)

Be ready for Number 31.

(Tunes)

Be ready for Number 41.

(Tunes)

That is the end of the test.

3. Scoring--number right. The key is in Appendix C.

Statistical Results

Data will be presented on the 388 entering radio operator trainees.

1. Distribution statistics. A mean of 33.84 and a standard deviation of 6.54 were obtained on the sample of airmen. This compares with a mean of 37.8 and a standard deviation of 6.7 obtained by White (7) on a sample of 116 high school students.

2. Reliability. The split-half off-even reliability coefficient was .78. This coefficient is appropriate on this case, as the test is not speeded. White obtained a Kuder-Richardson Formula No. 20 reliability of .83.

3. Difficulty. The mean proportion of items answered correctly is .68 for the sample of entering radio operator trainees.

4. *Intercorrelations with other measures.* Table 7 presents the intercorrelations of Hidden Tunes with Airman Classification Battery variables, and Table 3 presents the correlations with other auditory measures. It is clear that the test has more in common with other auditory measures than with printed measures.

White (7) had shown that Hidden Tunes correlated highly with certain printed tests of "closure." For example, correlations of .66 and .57 were obtained with the Concealed Figure and Mutilated Words tests, respectively. We obtained correlations of .25 and .20 with these two tests. The reasons for these discrepancies are not yet clear.

5. *Factorial content.* The analysis by Fleishman, Roberts, and Friedman (3) indicates that Hidden Tunes was one of the best measures of the Auditory Rhythm Perception factor (loading = .62).

6. *Test validity.* A validity coefficient of -.21 was obtained with the number of days required to reach a speed of 14~~8~~ groups per minute in receiving Morse Code. More complete data are under study by the authors.

OTHER AUDITORY MEASURES

The six subtests of the Seashore Measures of Musical Talents[2] have been adapted for Air Force use in previous studies (2, 4). One of these, Rhythm Discrimination, has gone through several revisions, and now has been incorporated into the Airman Classification Battery AC-2A as Part I of the Air Force Aural Code test. This test is used to select airmen for radio operator training. The development of this test has been described fully elsewhere (2) and will not be repeated here.

The minor modifications made in the other five Seashore subtests have been described by Fleishman and Spratte (4). The major changes made were to record standard instructions on tape, together with demonstration examples. The original Seashore measures did not have sufficiently standardized instructions, and left the demonstration to the discretion of the examiner. The new revisions were more suitable for group administration. These new instructions developed by Fleishman and Spratte and the intercorrelations among these tests are described in their publication (4).

---

[2] Permission to adapt these tests for our use was obtained from Dr. Harold Seashore and the Psychological Corporation.

To complete the picture of auditory tests, we will present a brief summary of each of these tests.

Pitch Discrimination

A series of 50 pairs of tones differing in pitch is used. The examinee prints H if the second tone is higher and L if the second tone is lower in each pair. Administration time is 7.5 minutes. A mean of 36.5 (standard deviation of 7.2) and a split-half reliability of .86 were obtained on 243 unselected basic airmen. The test had a validity of .20 in predicting Morse Code proficiency.

Loudness Discrimination

A series of 50 pairs of tones differing in loudness (intensity or strength) is used. The examinee prints S if the second tone is stronger and W if the second tone is weaker in each pair. Administration time is 7.5 minutes. A mean of 36.65 (SD = 2.12) and split-half reliability of .63 were obtained on a sample of 243 unselected basic airmen. A validity coefficient of only .17 was obtained against a criterion of Morse Code proficiency.

Time Discrimination

A series of 50 pairs of tones which differ in length is used. The examinee prints L if the second tone is longer and S if the second tone is shorter. Administration time is 6 minutes. A mean of 38.56 (SD = 4.94) and a split-half reliability of .73 was obtained on a sample of 243 unselected basic airmen. A validity of .21 was obtained against a criterion of Morse Code proficiency.

Timbre Discrimination

A series of 50 pairs of tones differing in timbre, or tone quality is used. The examinee prints S if the tone in each pair are the same and D if they are different. Administration time is 6 minutes. A mean of 38.82 (SD = 5.60) and a split-half reliability of .79 were obtained on a sample of 243 unselected basic airmen. A validity of .21 was obtained against a criterion of Morse Code proficiency.

Tonal Memory

A series of 30 pairs of tone patterns is used. In the second pattern of each pair, one note is changed. The examinee listens to the first pattern in each pair, and then marks the number of the note that is changed in the second patterns, e.g., a 1, if the first note is changed, and a 2, if the second note is changed, etc. Administration time is 7.5 minutes. A mean of 19.08 (SD = 6.96) and a split-half reliability of .88 were obtained with a sample of 243 unselected basic airmen. A validity of .27 was obtained against a criterion of Morse Code proficiency.

Rhythm Discrimination

The development of a highly refined version of this test has been presented recently (2). The final revision involves a series of 70 pairs of rhythmic patterns (beats within each pattern presented in rapid succession). The examinee marks under S on the IBM answer sheet if the patterns are the same, under D if they are different, and under a ? if he cannot decide. Administration time of this final form (Form D) is 16 minutes. A mean of 49.5 (SD = 10.6) was obtained on a sample of 215 basic airmen. The split-half reliability is .90. The test is now included as Part I of the Air Force Aural Code test, used to select airmen for radio operator training. A representative validity coefficient of this test for predicting code proficiency is .30.

Two other aural tests described elsewhere may be mentioned briefly.

The Signal Corps Code Aptitude Test (See 1, 4.)

A series of 78 pairs of actual Morse Code signal patterns are presented. The examinee marks if the signal groups in each pair are the same or different. Administration time is 18.5 minutes. This test was used operationally for a brief time in 1952-1953 to select radiotelegraphers in the Air Force, but was replaced in 1953 by the Army Radio Code test. In the sample of 243 basic airmen the test had a mean of 51.17 (SD = 7.53) and a split-half reliability of .74. Validity for predicting a code proficiency criterion was found to be .33.

The Army Radio Code Test (See 1, 2, 4.)

The examinee is required to learn to receive the Morse Code signals for I, N, and T, during an intensive 27-minute practice session. A final

3 minutes consists of 150 test items in which he receives the signals at a very high rate of speed. Answers in practice and on the test are recorded on an IBM answer sheet. The test was used to select airmen for radio operator training from 1953 through 1956. The reliability of the test was above .95 with a mean of 53.5 and a SD of 33.5 using the scoring formula (R—1/2W). Since January 1957 a shortened form of this test has been used as Part II of the new Air Force Aural Code test.

SUMMARY

This report has summarized the available information on a number of auditory-perceptual tests standardized in the Operator Laboratory, Air Force Personnel and Training Research Center. Four of these tests, Copying Behind, Dot Perception, Code Distraction, and Hidden Tunes, were described in detail. Brief summaries of other auditory tests, which have been described in previous reports, were presented. These included Pitch, Loudness, Time, Timbre, Tonal Memory, and Rhythm Discrimination which are adaptations of the Seashore Measures of Musical Talents. The Signal Corps Code Aptitude test and the Army Radio Code, which were formerly operational in the Airman Classification Batteries, also were described. References to more complete descriptions of the latter tests were provided.

REFERENCES

1. CREAGER, J. A. *Comparative validation of two radio code tests when used with the Airman Classification Battery in selecting radio operator trainees.* Lackland Air Force Base, Tex.: Air Force Personnel and Training Research Center, November 1954. (*Technical Report* AFPTRC-TR-54-65.)

2. FLEISHMAN, E. A., & FRIEDMAN, M. P. *The development of the Air Force Aural Code Test.* Lackland Air Force Base, Tex.: Air Force Personnel and Training Research Center, November 1957. (*Research Report* AFPTRC-TN-57-131, ASTIA Document No. AD 146 404.)

3. FLEISHMAN, E. A., ROBERTS, M. M., & FRIEDMAN, M. P. A factor analysis of aptitude and proficiency measures in radiotelegraphy. *J. appl. Psychol.*, in press.

4. FLEISHMAN, E. A., & SPRATTE, J. G. *The prediction of radio operator success by means of aural tests*. Lackland Air Force Base, Tex.: Air Force Personnel and Training Research Center, November 1954. (*Technical Report* AFPTRC-TR-54-66.)

5. HIGHLAND, R. W., & FLEISHMAN, E. A. An empirical classification of error patterns in receiving Morse Code. *J. appl. Psychol.*, in press.

6. THURSTONE, L. L. *A factorial study of perception*. Chicago: Univer. of Chicago Press, 1944.

7. WHITE, B. W. Visual and auditory closure. *J. exp. Psychol.*, 1954, *48*, 234-240.

APPENDIX E

COOPERATING INSTITUTIONS

COOPERATING INSTITUTIONS

No Experience Group

Central High School
Champaign, Illinois

First Year and Graduating Post High School Technical Students

Columbus Area Vocational-Technical School
Columbus, Georgia

DeKalb Area Vocational-Technical School
Clarkson, Georgia

Fayetteville County Technical School
Fayetteville, North Carolina

Griffin Area Vocational-Technical School
Griffin, Georgia

Savannah Area Vocational-Technical School
Savannah, Georgia

South Georgia Technical and Vocational School
Americus, Georgia

Swainsboro Area Technical-Vocational School
Swainsboro, Georgia

Thomas Area Vocational-Technical School
Thomasville, Georgia

Troup Area Vocational-Technical School
LaGrange, Georgia

Waycross-Ware Area Vocational-Technical School
Waycross, Georgia

York County Technical Education Center
Rock Hill, South Carolina

Auto Mechanics

Northern Illinois University Motor Pool
DeKalb, Illinois

Purdue University Motor Pool
West Lafayette, Indiana

Southern Illinois University Motor Pool
Carbondale, Illinois

University of Illinois Motor Pool
Urbana, Illinois

APPENDIX F

EXPERIENCE SHEET

EXPERIENCE SHEET

Name____

School or employer______________________________________

Number of months of formal training in auto mechanics____

Number of months working as an auto mechanic____________

Check one

____________I do not have any hearing problems.

____________I have hearing problems.

Check one

____________Most of my diagnostic work has been done with test equipment.

____________Most of my diagnostic work has been done without test equipment.

Circle one

I know Chevrolet, Ford, Plymouth cars best.

APPENDIX G

AAMDAT ITEM INFORMATION AND ITEM ANALYSIS

AAMDAT ITEM INFORMATION FOR THE TOTAL GROUP*

TEST ITEM	PERCENT PASSING	CORRECT ANSWER	PROPORTATION SELECTING EACH RESPONSE A	B	C	D
2	.643	D	.275	.052	.030	.643
3	.364	C	.309	.245	.364	.082
4	.680	A	.680	.033	.212	.074
5	.115	A	.115	.178	.628	.078
6	.476	B	.138	.476	.305	.082
7	.454	D	.141	.138	.268	.454
8	.625	B	.283	.625	.041	.052
9	.550	B	.197	.550	.216	.037
10	.257	C	.082	.178	.257	.483
11	.550	A	.550	.435	.015	.000
12	.595	D	.123	.182	.100	.595
13	.472	A	.472	.283	.178	.167
14	.416	A	.416	.167	.152	.264
15	.309	B	.331	.309	.279	.082
16	.550	B	.104	.550	.230	.115
17	.937	D	.004	.030	.030	.937
18	.115	A	.115	.067	.502	.316
19	.446	C	.178	.134	.446	.242
20	.807	C	.052	.048	.807	.093
21	.483	C	.112	.208	.483	.197
22	.465	B	.167	.465	.175	.193
23	.312	D	.126	.130	.431	.312
24	.517	B	.249	.517	.134	.100
25	.186	A	.186	.138	.178	.498
26	.550	B	.227	.550	.086	.138
27	.688	A	.688	.149	.130	.033
28	.375	D	.238	.305	.082	.275
29	.792	B	.037	.792	.033	.138
30	.680	C	.134	.100	.680	.086
31	.840	C	.056	.059	.840	.045
32	.335	D	.126	.037	.502	.335
33	.141	B	.416	.141	.283	.160
34	.520	C	.108	.171	.520	.201
35	.253	B	.268	.253	.320	.160
36	.461	A	.461	.086	.249	.204
37	.461	A	.461	.138	.230	.171
38	.242	C	.115	.305	.242	.338
39	.554	D	.119	.212	.115	.554
40	.216	C	.647	.082	.216	.056
41	.353	B	.242	.353	.253	.152
42	.543	B	.149	.543	.197	.112
43	.584	A	.584	.193	.178	.045
44	.465	D	.089	.033	.413	.465
45	.662	B	.082	.662	.223	.033

*269 Subjects

AAMDAT ITEM ANALYSIS FOR THE TOTAL GROUP*

ITEM NUMBER	PROPORTION PASSING	BISERIAL R ITEM-TOTAL	PT. BISERIAL R ITEM-TOTAL
2	.643	.466	.363
3	.364	.518	.404
4	.680	.589	.452
5	.115	-.257	-.156
6	.476	.589	.470
7	.454	.191	.152
8	.625	.354	.277
9	.550	.210	.167
10	.257	.214	.158
11	.550	.288	.229
12	.595	.139	.110
13	.472	.380	.303
14	.416	.537	.425
15	.309	.372	.284
16	.550	.510	.406
17	.937	.628	.320
18	.115	.065	.040
19	.446	.254	.202
20	.807	.566	.393
21	.483	.351	.280
22	.465	.300	.239
23	.312	.317	.242
24	.517	.253	.202
25	.186	-.123	-.084
26	.550	.453	.360
27	.688	.435	.332
28	.375	.465	.364
29	.792	.495	.350
30	.680	.610	.467
31	.840	.565	.375
32	.335	.212	.163
33	.141	-.160	-.103
34	.520	.668	.533
35	.253	.531	.533
36	.461	.395	.315
37	.461	.398	.318
38	.242	.122	.089
39	.554	.412	.328
40	.216	-.058	-.041
41	.353	.296	.230
42	.543	.494	.394
43	.584	.467	.370
44	.465	.369	.294
45	.662	.317	.245

*269 Subjects

AAMDAT ITEM INFORMATION FOR THE NO EXPERIENCE GROUP*

TEST ITEM	PERCENT PASSING	CORRECT ANSWER	PROPORTATION SELECTING EACH RESPONSE			
			A	B	C	D
2	.433	D	.418	.119	.030	.433
3	.134	C	.373	.478	.134	.015
4	.299	A	.299	.134	.358	.209
5	.284	A	.284	.284	.224	.209
6	.194	B	.313	.194	.284	.209
7	.373	D	.149	.119	.358	.373
8	.478	B	.313	.478	.104	.104
9	.478	B	.194	.478	.269	.060
10	.194	C	.224	.149	.194	.433
11	.388	A	.388	.612	.000	.000
12	.582	D	.104	.090	.224	.582
13	.239	A	.239	.358	.343	.060
14	.104	A	.104	.224	.299	.373
15	.224	B	.299	.224	.299	.179
16	.254	B	.224	.254	.358	.164
17	.776	D	.015	.119	.090	.776
18	.134	A	.134	.045	.597	.224
19	.343	C	.179	.299	.343	.179
20	.567	C	.149	.119	.567	.164
21	.358	C	.119	.239	.358	.284
22	.313	B	.134	.313	.418	.134
23	.194	D	.388	.194	.224	.194
24	.373	B	.164	.373	.209	.254
25	.269	A	.269	.209	.284	.239
26	.373	B	.313	.373	.134	.179
27	.463	A	.463	.194	.269	.075
28	.209	D	.224	.448	.119	.209
29	.582	B	.060	.582	.030	.328
30	.313	C	.313	.239	.313	.134
31	.701	C	.134	.104	.701	.060
32	.254	D	.179	.075	.493	.254
33	.224	B	.269	.224	.254	.254
34	.090	C	.030	.433	.090	.448
35	.104	B	.239	.104	.403	.254
36	.343	A	.343	.149	.239	.269
37	.269	A	.269	.254	.239	.239
38	.254	C	.179	.313	.254	.254
39	.418	D	.164	.269	.149	.418
40	.328	C	.463	.164	.328	.045
41	.209	B	.373	.209	.299	.119
42	.284	B	.090	.284	.403	.224
43	.269	A	.269	.493	.119	.119
44	.299	D	.239	.090	.373	.299
45	.552	B	.134	.552	.269	.045

*67 Subjects

AAMDAT ITEM ANALYSIS FOR THE NO EXPERIENCE GROUP*

ITEM NUMBER	PROPORTION PASSING	BISERIAL R ITEM-TOTAL	PT. BISERIAL R ITEM-TOTAL
2	.433	.372	.295
3	.134	.213	.135
4	.299	.030	.023
5	.284	.363	.272
6	.194	.448	.312
7	.373	-.022	-.017
8	.478	.290	.231
9	.478	.003	.002
10	.194	.077	.054
11	.388	.281	.221
12	.582	.027	.022
13	.239	.377	.274
14	.104	.188	.111
15	.224	.289	.207
16	.254	.448	.329
17	.776	.339	.243
18	.134	.175	.111
19	.343	.189	.146
20	.567	.240	.191
21	.358	.202	.157
22	.313	.231	.176
23	.194	.374	.260
24	.373	.075	.059
25	.269	.292	.217
26	.373	.420	.329
27	.463	.378	.301
28	.209	.322	.228
29	.582	.299	.237
30	.313	.334	.255
31	.701	.394	.298
32	.254	.307	.226
33	.244	.207	.148
34	.090	-.231	-.131
35	.104	.075	.045
36	.343	.455	.352
37	.269	.205	.153
38	.254	.205	.151
39	.418	.297	.235
40	.328	.153	.117
41	.209	-.004	-.003
42	.284	.097	.73
43	.269	.317	.236
44	.299	.477	.362
45	.552	.389	.309

* 67 Subjects

AAMDAT ITEM INFORMATION FOR FIRST YEAR AUTO MECHANIC STUDENTS*

TEST ITEM	PERCENT PASSING	CORRECT ANSWER	PROPORTATION SELECTING EACH RESPONSE A	B	C	D
2	.692	D	.220	.044	.044	.692
3	.352	C	.308	.264	.352	.077
4	.791	A	.791	.000	.176	.033
5	.077	A	.077	.220	.626	.077
6	.571	B	.088	.571	.286	.055
7	.396	D	.165	.176	.264	.396
8	.648	B	.308	.648	.011	.033
9	.516	B	.196	.516	.242	.044
10	.297	C	.022	.187	.297	.495
11	.604	A	.604	.385	.011	.000
12	.516	D	.198	.242	.044	.516
13	.451	A	.451	.341	.132	.077
14	.440	A	.440	.121	.121	.319
15	.264	B	.352	.264	.319	.066
16	.604	B	.077	.604	.198	.121
17	1.000	D	.000	.000	.000	1.000
18	.143	A	.143	.088	.473	.297
19	.396	C	.176	.121	.396	.308
20	.857	C	.000	.044	.857	.099
21	.351	C	.143	.264	.341	.253
22	.516	B	.198	.516	.077	.209
23	.341	D	.044	.121	.495	.341
24	.571	B	.242	.571	.121	.066
25	.187	A	.187	.121	.165	.527
26	.538	B	.257	.538	.066	.121
27	.703	A	.703	.154	.132	.011
28	.363	D	.231	.319	.088	.373
29	.879	B	.011	.879	.033	.077
30	.758	C	.110	.055	.758	.077
31	.857	C	.033	.077	.857	.033
32	.374	D	.143	.022	.462	.374
33	.121	B	.505	.121	.165	.209
34	.615	C	.110	.077	.615	.198
35	.187	B	.319	.187	.374	.121
36	.462	A	.462	.066	.264	.209
37	.429	A	.429	.132	.242	.198
38	.220	C	.132	.242	.220	.407
39	.593	D	.044	.220	.143	.593
40	.176	C	.714	.066	.176	.044
41	.319	B	.242	.319	.308	.132
42	.582	B	.132	.582	.187	.099
43	.670	A	.670	.099	.220	.011
44	.527	D	.077	.011	.385	.527
45	.670	B	.088	.670	.198	.044

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*91 Subjects

AAMDAT ITEM ANALYSIS FOR FIRST YEAR AUTO MECHANIC STUDENTS*

ITEM NUMBER	PROPORTION PASSING	BISERIAL R ITEM-TOTAL	PT. BISERIAL R ITEM-TOTAL
2	.692	.297	.226
3	.352	.539	.419
4	.791	.358	.253
5	.077	-.084	-.045
6	.571	.642	.510
7	.396	.064	.051
8	.648	.088	.069
9	.516	.148	.118
10	.297	.214	.162
11	.604	.256	.201
12	.516	.218	.174
13	.451	.218	.173
14	.440	.280	.222
15	.264	.234	.173
16	.604	.227	.179
17	1.000	.000	.000
18	.143	.186	.120
19	.396	.334	.263
20	.857	.323	.208
21	.341	.122	.094
22	.516	.134	.107
23	.341	.175	.136
24	.571	.236	.187
25	.187	-.011	-.011
26	.538	.309	.247
27	.703	.102	.077
28	.363	.409	.319
29	.879	.401	.247
30	.758	.418	.305
31	.857	.422	.272
32	.373	.126	.099
33	.121	.115	.071
34	.615	.510	.401
35	.187	.402	.277
36	.462	.488	.389
37	.429	.336	.266
38	.220	.281	.201
39	.593	.396	.313
40	.176	-.042	-.028
41	.319	.284	.217
42	.582	.354	.281
43	.670	.337	.259
44	.527	.165	.132
45	.670	.081	.062

*91 Subjects

AAMDAT ITEM INFORMATION FOR GRADUATING AUTO MECHANIC STUDENTS*

TEST	PERCENT	CORRECT	PROPORTATION SELECTING EACH RESPONSE			
ITEM	PASSING	ANSWER	A	B	C	D
2	.687	D	.254	.030	.030	.687
3	.433	C	.313	.134	.433	.119
4	.821	A	.821	.000	.164	.015
5	.030	A	.030	.060	.910	.000
6	.433	B	.075	.433	.463	.030
7	.537	D	.134	.134	.194	.537
8	.687	B	.224	.687	.030	.060
9	.642	B	.164	.642	.179	.015
10	.269	C	.060	.164	.269	.507
11	.612	A	.612	.373	.015	.000
12	.567	D	.104	.269	.060	.567
13	.612	A	.612	.149	.149	.090
14	.597	A	.597	.134	.119	.149
15	.209	B	.403	.209	.343	.045
16	.657	B	.045	.657	.209	.090
17	1.000	D	.000	.000	.000	1.000
18	.045	A	.045	.045	.537	.373
19	.612	C	.104	.045	.612	.239
20	.881	C	.045	.015	.881	.060
21	.627	C	.104	.179	.627	.090
22	.522	B	.194	.522	.045	.239
23	.284	D	.045	.104	.567	.284
24	.463	B	.373	.463	.119	.045
25	.194	A	.194	.075	.134	.597
26	.567	B	.209	.567	.075	.149
27	.776	A	.776	.134	.060	.030
28	.373	D	.284	.269	.075	.373
29	.836	B	.060	.836	.015	.090
30	.836	C	.045	.045	.836	.075
31	.866	C	.045	.030	.866	.060
32	.463	D	.090	.030	.418	.463
33	.119	B	.463	.119	.343	.075
34	.657	C	.164	.119	.657	.060
35	.224	B	.313	.224	.343	.119
36	.493	A	.493	.045	.313	.149
37	.567	A	.567	.090	.164	.179
38	.254	C	.060	.299	.254	.388
39	.552	D	.149	.209	.090	.552
40	.149	C	.761	.060	.149	.030
41	.478	B	.149	.478	.194	.079
42	.657	B	.254	.657	.060	.030
43	.672	A	.672	.104	.179	.045
44	.522	D	.015	.030	.433	.522
45	.716	B	.045	.716	.209	.030

*67 Subjects

AAMDAT ITEM ANALYSIS FOR GRADUATING AUTO MECHANIC STUDENTS*

ITEM NUMBER	PROPORTION PASSING	BISERIAL R ITEM-TOTAL	PT. BISERIAL R ITEM-TOTAL
2	.687	.534	.408
3	.433	.249	.198
4	.821	.668	.456
5	.030	-.079	-.031
6	.433	.239	.190
7	.537	.175	.139
8	.687	.469	.358
9	.642	.224	.174
10	.269	.427	.318
11	.612	.121	.095
12	.567	-.092	-.073
13	.612	-.070	-.055
14	.597	.451	.356
15	.209	.420	.297
16	.657	.320	.247
17	1.000	.000	.000
18	.045	.181	.082
19	.612	.151	.119
20	.881	.417	.256
21	.627	.263	.206
22	.522	.496	.395
23	.284	.197	.148
24	.463	.068	.054
25	.194	.063	.044
26	.567	.222	.176
27	.776	.218	.156
28	.373	.328	.256
29	.836	.500	.335
30	.836	.205	.137
31	.866	.583	.370
32	.463	.340	.271
33	.119	-.262	-.261
34	.657	.330	.256
35	.224	.504	.362
36	.493	.189	.151
37	.567	.124	.098
38	.254	.141	.104
39	.552	.427	.340
40	.149	.200	.131
41	.478	.066	.052
42	.657	.445	.345
43	.672	.099	.076
44	.522	.389	.310
45	.716	.418	.314

*67 Subjects

AAMDAT ITEM INFORMATION FOR THE AUTO MECHANICS*

TEST ITEM	PERCENT PASSING	CORRECT ANSWER	PROPORTATION SELECTING EACH RESPONSE A	B	C	D
2	.795	D	.205	.000	.000	.795
3	.636	C	.205	.023	.636	.136
4	.818	A	.818	.000	.136	.045
5	.068	A	.068	.114	.818	.000
6	.773	B	.068	.773	.136	.023
7	.568	D	.091	.091	.150	.568
8	.705	B	.273	.705	.023	.000
9	.591	B	.250	.591	.136	.023
10	.250	C	.023	.227	.250	.500
11	.591	A	.591	.364	.045	.000
12	.818	D	.023	.068	.091	.818
13	.659	A	.659	.250	.068	.023
14	.568	A	.568	.227	.045	.159
15	.682	B	.227	.682	.068	.023
16	.727	B	.068	.727	.136	.068
17	.955	D	.000	.000	.045	.955
18	.136	A	.136	.091	.364	.409
19	.455	C	.295	.045	.455	.205
20	.955	C	.023	.000	.955	.023
21	.750	C	.045	.091	.750	.114
22	.500	B	.114	.500	.205	.182
23	.477	D	.023	.091	.409	.477
24	.705	B	.205	.705	.068	.023
25	.045	A	.045	.159	.114	.782
26	.818	B	.023	.818	.068	.091
27	.864	A	.864	.091	.023	.023
28	.659	D	.205	.114	.023	.659
29	.864	B	.023	.864	.068	.045
30	.841	C	.045	.068	.841	.045
31	.977	C	.000	.000	.977	.023
32	.182	D	.068	.023	.727	.182
33	.091	B	.386	.091	.477	.045
34	.773	C	.136	.045	.773	.045
35	.659	B	.136	.659	.045	.159
36	.591	A	.591	.091	.136	.182
37	.659	A	.659	.045	.295	.000
38	.250	C	.068	.432	.250	.250
39	.682	D	.159	.114	.045	.682
40	.227	C	.614	.023	.227	.136
41	.455	B	.182	.455	.159	.205
42	.682	B	.114	.682	.114	.091
43	.750	A	.750	.068	.182	.000
44	.500	B	.000	.000	.500	.500
45	.727	B	.045	.727	.227	.000

*44 Subjects

AAMDAT ITEM ANALYSIS FOR THE AUTO MECHANICS*

ITEM NUMBER	PROPORTION PASSING	BISERIAL R ITEM-TOTAL	PT. BISERIAL R ITEM-TOTAL
2	.795	-.017	-.012
3	.564	.124	.097
4	.818	.075	.051
5	.068	.030	.016
6	.773	.274	.198
7	.568	.287	.228
8	.705	.473	.358
9	.591	.499	.395
10	.250	.105	.077
11	.591	.065	.051
12	.818	.128	.088
13	.659	.137	.106
14	.568	.341	.271
15	.682	.112	.086
16	.727	.291	.217
17	.955	.291	.134
18	.136	.069	.044
19	.455	.061	.049
20	.955	.512	.235
21	.750	.360	.264
22	.500	.026	.021
23	.477	.229	.183
24	.705	.004	.003
25	.045	-.512	-.235
26	.818	.474	.325
27	.864	.285	.182
28	.659	.252	.195
29	.864	.060	.038
30	.841	.300	.199
31	.977	.842	.306
32	.182	.510	.350
33	.091	-.470	-.267
34	.773	.717	.516
35	.659	.329	.255
36	.591	.300	.237
37	.659	.272	.210
38	.250	.039	.028
39	.682	.467	.358
40	.227	.262	.188
41	.455	.310	.247
42	.682	.526	.403
43	.750	-.039	-.028
44	.500	.379	.302
45	.727	.333	.248

*44 Subjects

APPENDIX H

ROTATED SIX FACTOR ANALYSIS ON THE AAMDAT

ROTATED SIX FACTOR ANALYSIS ON THE AAMDAT

Item	Communality	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
2	.281	.482	-.120	.031	.029	.064	.168
[illegible]	.381	.101	-.402	.425	.124	-.001	.118
[illegible]	.375	.563	-.130	.164	.117	-.020	.017
5	.080	-.225	.100	.059	.025	.050	-.111
6	.520	.531	-.035	.018	.416	-.122	.222
7	.126	.104	-.152	.016	-.294	.057	.045
8	.323	.398	.066	-.148	.371	-.026	-.024
9	.156	.074	.069	.061	.145	-.334	-.098
10	.108	.014	-.073	.033	.285	.064	-.127
11	.280	.160	-.073	.169	.090	.094	.451
12	.162	-.060	-.292	-.038	.032	.074	-.255
13	.364	.275	-.285	-.104	-.088	-.435	-.006
14	.358	.442	-.218	.198	.144	-.220	-.080
15	.149	.019	-.285	.031	.234	-.016	.107
16	.273	.331	-.260	.213	-.030	-.233	.011
17	.055	.166	-.019	.155	.034	.031	-.036
18	.023	-.008	-.035	-.130	.052	.024	.036
19	.209	.173	-.153	.016	.018	.090	-.383
20	.174	.205	-.211	.249	.106	-.119	.005
21	.228	.105	-.436	.145	-.072	-.028	.004
22	.283	.134	-.036	.235	-.063	-.400	.211
23	.217	-.019	-.183	.051	.401	-.005	.141
24	.291	.206	-.016	-.050	.187	.458	-.036
25	.115	-.164	.142	.058	.011	.114	-.226
26	.378	.049	-.410	.180	.140	-.319	.233
27	.178	.227	-.281	.062	.160	.119	-.067
28	.444	.180	-.223	.060	.446	-.032	.398
29	.259	.436	-.036	.181	-.175	.018	.066
30	.376	.462	-.165	.178	.197	-.226	.119
31	.132	.249	-.113	.201	.111	.042	-.048
32	.149	.225	.144	.017	.109	-.122	-.226
33	.071	-.051	.030	-.180	-.182	.019	.046
34	.530	.468	-.239	.440	.082	-.140	.188
35	.296	.189	-.484	.141	-.019	-.077	-.004
36	.175	.219	-.065	.285	.048	-.141	.141
37	.422	.142	-.589	-.200	.102	-.009	.067
38	.182	.076	-.069	-.266	.025	.110	.296
39	.344	.282	-.083	.396	-.005	.310	.070
40	.118	-.278	.054	-.017	.171	-.066	.070
41	.127	.210	-.245	-.057	-.043	.134	.019
42	.380	.400	.034	.430	.173	.018	.068
43	.399	.548	-.131	.184	-.163	-.035	-.139
44	.307	.021	-.066	.531	.107	-.080	.043
45	.352	.110	.029	.192	.460	.160	-.254
S.S.	11.150	3.281	2.025	1.833	1.545	1.244	1.223
Pct. Com.		29.42	18.16	16.44	13.85	11.16	10.97